PLEASE REFER TO FILE FOLDER NO. 7

FOR THE CONTINUATION OF THIS WATER RIGHT FILE

No. 63-32089

CITY OF EAGLE

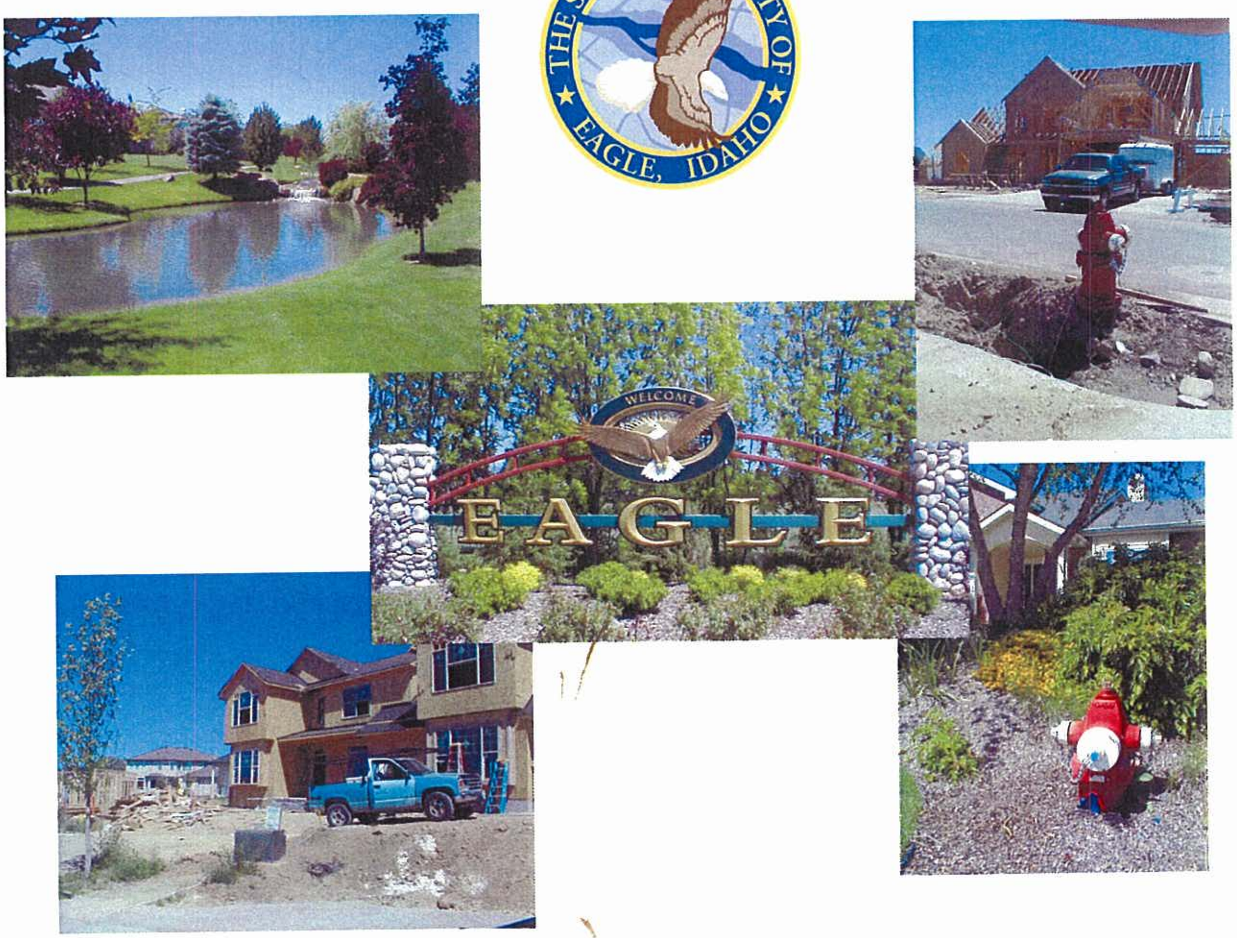
Municipally Owned Water System

PWS #4010201

AMENDED MASTER PLAN

Revised November 2005

Volume II
Operation & Maintenance



HOLLADAY ENGINEERING COMPANY

32 N. Main Street P.O. Box 235 Payette, ID 83661
(208) 642-3304 fax (208) 642-2159
e-mail: hec@holladayengineering.com

EG051404

EXHIBIT
5 (cont.)

STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY

1410 North Hilton • Boise, Idaho 83706-1255 • (208) 373-0502

Dirk Kempthorne, Governor
Toni Hardesty, Director

ORIGINAL STAMPED APPROVAL COPIES ARE HOUSED AT 1)HOLLADAY ENGINEERING COMPANY, 32 N. MAIN STREET, PAYETTE, IDAHO, 2)EAGLE CITY HALL, 310 EAST STATE STREET, EAGLE, IDAHO (AFTER APRIL 2006 EAGLE CITY HALL'S ADDRESS WILL BE 660 CIVIC LANE, EAGLE, IDAHO), AND AT 3)IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY, STATE OFFICE, 1410 NORTH HILTON STREET, BOISE, IDAHO.

TSCPE-126/2005

December 30, 2005

The Honorable Nancy Merrill
Mayor of Eagle
City of Eagle City Hall
P.O. Box 1520
Eagle, Idaho 83616

RE: City of Eagle, Master Plan and Budget Study *(Eagle, Ada County)*
Public Water System Master Plan

Dear Mayor Merrill:

The amended master plan and budget study for the above project appear to meet state of Idaho standards, and are approved. The standard conditions on the Department of Environmental Quality (DEQ) review stamp are part of this approval. Supporting reports or documents are considered to be part of the approved documents.

Please call me with any questions at (208) 373-0582, or via e-mail at diane.baconguis@deq.idaho.gov.

Sincerely,

Diane Baconguis

Diane Baconguis, E.I.T.
Idaho Department of Environmental Quality

DB:sjt
Enclosures: One Set of Approved and Stamped Master Plans

C: Charles W. Ariss, P.E., Regional Engineering Manager, DEQ Boise Regional Office
Todd Crutcher, DEQ Boise Regional Office
Mark Clough, P.E., DEQ Technical Services
Larry Waters, E.I.T., DEQ Technical Services
Kenneth R. Rice, P.E., Holladay Engineering Company *(w/ one set approved and stamped master plan)*
Central District Health Department, Ada County Office
Source File 2, City of Eagle, Master Plan and Budget Study, Manager's File
TSCPE Reading File

CITY OF EAGLE

Municipally Owned Water System

PWS #4010201

AMENDED MASTER PLAN

Revised November 2005

Volume II

Operation & Maintenance

REGISTERED PROFESSIONAL ENGINEER 3032 STATE OF IDAHO KENNETH R. RICE

Kenneth R. Rice 11-11-05

Prepared by:

HOLLADAY ENGINEERING COMPANY

32 N. Main Street P.O. Box 235 Payette, ID 83661
(208) 642-3304 fax (208) 642-2159
e-mail: hec@holladayengineering.com

EG051404

TABLE OF CONTENTS
VOLUME II APPENDICES I-J-K-L
Revised November 2005

APPENDIX I
Operation and Maintenance

APPENDIX I
OPERATION AND MAINTENANCE

CHAPTER 1: INTRODUCTION

A. Purpose of Manual
The purpose of this manual is to serve as a primary information reference for staff operating and supervising operation of the City of Eagle's municipally owned potable water system. Information incorporated includes basic task lists and schedules, operating procedure information and information from equipment and material suppliers. Division of staff and contract operator responsibilities is also discussed in general, and major role assignments are defined. It is planned that amendments will be made to update this manual whenever there are any major changes in the system's physical facilities or organizational structure.

B. Organization and Duties
Direct operation of the facilities is at the time of this writing performed by a contract operator, United Water Operations, Inc., a division of United Water Idaho, Inc. (UWI). City of Eagle staff members who have direct duties relative to system operation and maintenance are the City Clerk/Treasurer, who is responsible for administration and accounting of Water Account funds, and the Facilities Manager, who is the City's ex-officio water department manager and agent in dealings with the operations contractor. The Facilities Manager reports to the Mayor, and may consult the City Engineer, the City Attorney or other members of the City staff with regard to specialized issues requiring the particular expertise of other staff.

CHAPTER 2: STANDARDS AND RULES

Directly applicable rules governing operation and maintenance of this water system are the Idaho Rules for Public Drinking Water Systems (IDAPA 58.01.08), a chapter of the Idaho Administrative Rules. The principal systems of trade-association standards required by these rules are the applicable parts of AWWA and ANSI standards, and NSF 61 for materials in contact with drinking water.

CHAPTER 3: FACILITIES

A. System Service Area and Capacity Requirements
The City of Eagle's Municipally Owned Water System serves an aggregation of developments located north of Floating Feather Road, west of Horseshoe Bend Road, south of Dry Creek and east of Eagle Road. Development complexes

included are the Lexington Hills, Trail Creek, Brookwood, Crown Point and Eagle Crest groups of subdivisions. Services are principally residential, but also include service to Sevenoaks School., an elementary school, and large diameter service connections for maintaining the water levels in amenity ponds in the common areas of the subdivisions during the off-season of the irrigation company. The number of service connections, calculated as Equivalent Residential Customers (ERCs) based on the ratio of meter flow capacity to ¾" meter flow capacity, was 1,255 as of Nov. 30, 2004 and is expected to reach approximately 1,350 ERCs at the completion of construction of houses on all the buildable lots in the subdivisions included in the current service area.

Based on water sales and production records, the system's projected water demand at build-out (1,350 ERCs) is average day 375,000 gallons, peak day 941,000 gallons and peak hour of peak day 1,411,900 gallons per day (equivalent flow rate). The peak-to-average ratios are abnormally high for this system because of the seasonal peaks of amenity pond use for make-up water. By deducting the recorded amenity pond use from the overall use, and applying the household size value (determined for Eagle by the 2000 U.S. Census) of 2.87 occupants per house, the annual average per capita use for water passing through the house meters during the most recent year of record has been found to be 86 gallons per capita per day.

B. Installed Facilities

The system has two wells, historically referred to as "Lexington Hills No. 1" and "Lexington Hills No. 2". In some recent documents, the more up-to-date designations "City of Eagle Well No. 1" and "City of Eagle Well No. 2" have been used. The numbering is the same in both nomenclatures.

There is a total of 99,313 feet of pipe in the distribution system, as of Dec. 2, 2004. See Appendix B of Volume I for a listing by diameter and listing of distribution system appurtenances by category. System has two service pressure zones, separated by two pressure reducing valve installations.

City of Eagle Well No.1 is located in its well lot within the common area enclosed by the loop street at the terminus of Stonybrook Court. It delivers water into the higher of the two pressure zones. The operating setpoint is a hydraulic grade line elevation (1929 NGVD) of 2840 feet MSL. This imposes a line pressure of about 79 psi at the well discharge, and an upper pressure zone pressure envelope of about 50 psi (in the main) at the highest elevation served and approximately 90 psi at the lowest elevation in the upper zone. Pressure reducing valves are set to maintain steady pressures, mostly between 60 and 90 psi (varying with elevation), in the lower pressure zone.

Well No. 1 is equipped with two submersible pumps that have VFD control in an electronic control loop that employs a pressure transducer on the receiving pipe as the primary sensing element for control. The pumps have fixed lead and lag assignments. The lead pump is a Gould submersible pump with a 30-hp Franklin motor and a full-speed capacity of approximately 250 gpm at the operating pressure. The lag pump is a Crown submersible, Model BL-600-4, with a 75-hp motor. Maximum production of this pump at operating pressure is approximately 600 gpm. The well is equipped with a Cla-Val pump control valve that automatically diverts the first rush of water and air to waste at pump startup, and gradually opens to direct water flow into the distribution system over a period of several seconds. The purpose of the pump control valve is threefold: to prevent introducing air, and potentially sediment, into the distribution system, to reduce power draft of the pump motor at startup, and to limit water hammer that would otherwise result from the high accelerations induced by pump startup. The pump control valve diversion outlets on both wells discharge through air gaps to dedicated drain lines that empty into the amenity pond system. Well No. 1 is also equipped with hypochlorination equipment for hydrogen sulfide neutralization and with a phosphate injection system for corrosivity control. Well No. 1 is integrated with the UWI SCADA system by means of an RTU at the site.

Well No. 1 is the only well in service in this system. Well No. 2 has experienced excessive and continuing sand production, and has unacceptable levels of iron and hydrogen sulfide, so it has been kept off line throughout most of the life of the system. Well No.2 has a single Crown Model BL-600-4 submersible pump with a 75-hp motor., across-the-line start, Cla-Val Pump Control Valve, Val-Matic check valve, gate valve, two McCrommeter flow meters and a pressure tank.

The system is intertied with the UWI distribution network. The intertie is the system's sole provision for emergency and breakdown backup. In general if Well No. 1 does not produce the flow volume that the system's users are demanding, some or all of three check or pressure reducing valves in lines connecting the City's distribution grid to the UWI distribution grid open and the United Water system automatically makes up the difference. The valves permit automatic passage of flow only from UWI to the City system at present. The UWI system operates at a lower setpoint than the upper pressure zone of the City system, so simple check valves are adequate control for cross-connecting to the upper zone. The lower pressure zone of the City system operates at a lower pressure setting than the UWI system, so a pressure-reducing valve with the low side set lower than the low-pressure-zone pressure setpoint is required to restrict valve operation to emergency situations for this zone. Actual connections from UWI to the City system are all to upper-zone pipes, and pressure reducing valves feeding the lower zone are all connected to the upper zone. At the intertie points, gate valves set in parallel with the check or pressure-reducing valves can potentially be operated under emergency conditions to deliver water from the City system to the UWI system as a mutual-aid measure. Since the UWI system has multiple wells, reservoirs, and several installations backed up by standby power, the intertie gives the City system excellent reliability of service.

CHAPTER 4: PERSONNEL

Personnel performing operation and maintenance tasks are required under the Idaho Rules for Public Drinking Water Systems to have operator's licenses of the appropriate class. For this system, the supervising operator is required to have a Class II Distribution System Operator's license. Required licensing of assistant operators varies according to their duty assignments.

CHAPTER 5: MAINTENANCE

A. Supply System

Currently, the supply system is for practical purposes Well No. 1, backed up by the intertie with UWI. The components of the system are the well itself, the pumps and motors, the variable-frequency drive, the Cla-Val pump control valve, the electrical service and control system, the chemical feed systems for chlorination and corrosion inhibition, and the check and shutoff valves at the wellhead.

Required routine maintenance of well-site equipment:

- General: perform janitorial maintenance and observe condition of equipment weekly;
- Pumps: record hour meter readings monthly, check and record power line leg amperages semi-annually, remove and perform major maintenance at ten-year intervals;
- Cla-Val pump control valve: clean pressure pilot line strainer annually, observe valve action (by forcing stop and start of pump) annually, disassemble to inspect and replace diaphragm and strainer screen at ten-year intervals;
- Magnetic flow meters: no routine maintenance. Compare totalizer reading change with difference in sum of service meter readings quarterly. If there is a discrepancy greater than 3 percent, test calibration of the magnetic meter as a first step in resolving the discrepancy;
- Electrical and VFD units: no routine maintenance. Consult manufacturer's service manual if VFD display screen shows a warning or alarm message;
- Corrosion inhibitor system:
- Chlorination system:

- Valves: observe closure effectiveness of Val-matic check valve, and exercise shutoff valve to confirm ability to close tightly, annually.

Well No.2 is off-line (shut-off valve closed) intentionally, but has value to the system as a potential withdrawal point for amenity make-up water. Hence, a program of maintenance is required in order to protect the well as a capital asset of the system.

Required routine maintenance of Well 2 equipment:
- Start pump, and discharge to waste for 20 minutes, annually to exercise shaft bearings;
- Check well house and perform janitorial maintenance monthly.

B. Distribution System
Required regular maintenance to be performed yearly or less frequently includes:
- Exercise line shut-off valves yearly,
- Flush mains and laterals at five-year intervals,
- Periodic hydrant testing: functional test as part of line flushing,
- Hydrant flow testing: selected hydrants, at random times, in partnership with Fire Department, or as required by the Eagle Fire District Fire Marshal,

Distribution system maintenance activities that will be performed only under special circumstances include:
- Pressure testing of existing pipelines,
- Sonic leak detection testing (by a specialty contractor),
- Disinfection of existing mains or laterals,
- Line, valve or other repair or replacement,
- Service pressure testing with portable pressure recorder (by a specialty contractor)

CHAPTER 6: SAMPLING AND TESTING

6.1 Monitoring Plan

Sampling is performed by qualified employees of the system operator, UWO. Analysis of samples is performed by a certified drinking water laboratory maintained by or contracted by the system operator. Currently, the system's sole source is Well No. 1. Monitoring frequencies for various categories of contaminants reflect the excellent quality record of this well, which has been in use for approximately 13 years.

Monitoring frequencies and numbers of samples

1.	Primary and Secondary Inorganic Contaminants (refer to 40 CFR 141.23): one sample at the well every three years
2.	Organic Contaminants except Trihalomethanes: one sample at the well every three years
3.	Trihalomethanes: one sample per year at a point maximally distant from the well
4.	Radionuclides: one sample at the well every four years
5.	Coliform bacteria: two samples per month, taken at in a set rotation from five established sampling sites in the system (see Appendix H, "Coliform Sampling Plan")
6.	Lead and Copper: required corrosivity indicators, at three tap sites once every three years. Required lead and copper samples at 20 tap sites (based on system having grown beyond a service population of 3,300 recently) every three years

6.2 Compliance Plan

Compliance actions, in general, relative to all results of monitoring, are;

1. Report all test results to DEQ on a timely basis as required by 40 CFR 141 for each specific test category.
2. Publish an annual Consumer Confidence Report based on the test data, as required by 40 CFR 141, Subpart O.
3. In the event of any Maximum Contaminant Level exceedance shown by any sample analysis performed under the Monitoring Plan, consult with DEQ to define the specific response program required, and commence and perform the required response in a timely manner.
4. In the event of bacterial or nitrate/nitrite limit exceedance, give prompt public notification at the first instance, and follow with added information as retesting procedure and further response actions are carried out.

CHAPTER 7: OPERATOR'S RECORDS

A. Operator's Records

- Operator shall maintain, as a minimum, the following records:
- Magnetic meter totalizer readings, weekly or more often (may use SCADA record as reference);
- Journal or marked check list of required system maintenance activities as listed foregoing, and building, grounds and vehicles maintenance, with dates;
- Quantities of chlorination and corrosion inhibitor chemicals loaded into equipment, and date of loading;
- Pump hour meter readings and dates.
- Annual tools and implements inventory, journal records of all tools and implements purchases and any disposal of obsolete or outworn tools and implements.
- Annual repair supplies inventory and journal of usage of repair supplies.

OPERATION & MAINTENANCE
EAGLE MUNICIPAL WATER
HECO Project # EG 051404

OPERATION CHECKLIST

Operator____________________
Date________________________

WELL NO. 1

Master Meter Reading ____________________ccf
Small Pump Hour Meter Reading ____________________hour
Large Pump Hour Meter Reading ____________________hour

Leg Voltages OK? ________ Yes ________ No
Comments____
____

Chlorine Solution Used ____________________lb
since____________________
Dose Rate ____________________
Metering Pumps OK? ____________________

Comments____
____

Corrosion inhibiter used ____________________lb
since____________________
Dose Rate ____________________
Metering Pumps OK? ____________________

Comments____
____

Repairs needed?____
____
____

WELL NO. 2

Operation Check Performed____________________
Date

by____________________
Name

Pump Start OK? ________ Yes ________ No

Condition of equipment, general

____

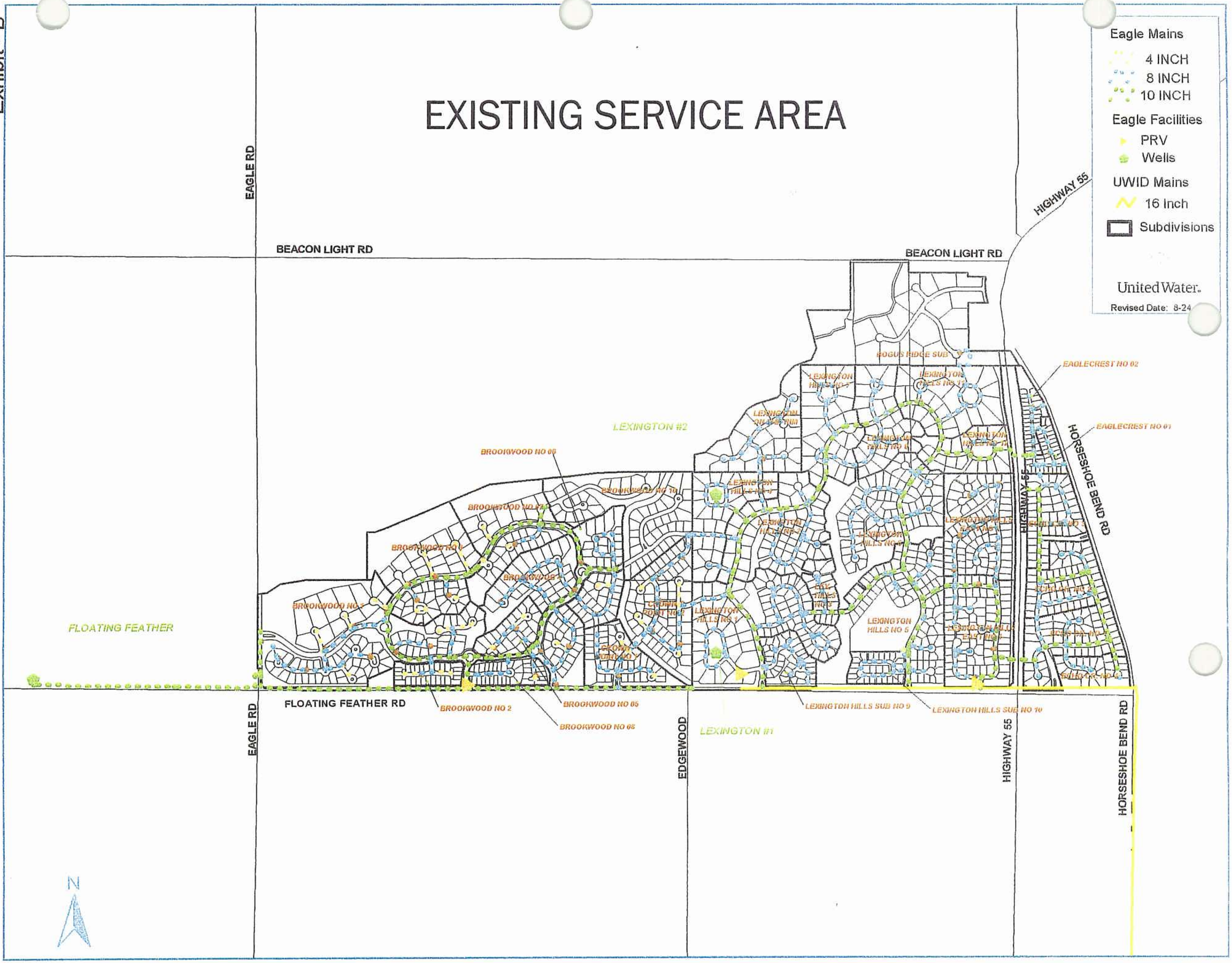
____

____

____

Exhibit - B

EXISTING SERVICE AREA



APPENDIX J
Cross Connection Control

APPENDIX J
CROSS-CONNECTION CONTROL

Cross-connection Control Plan:
Eagle City Code Item 6-5-13.C.2. states:

> *Cross Connections: A "cross-connection" is defined as any physical connection between the potable water system and another water supply.*
>
> *The City or its agent will not permit any unprotected cross connection and will discontinue service to any persons or premises where an unprotected cross connection exists. Service will not be restored until the cross connection is properly protected. Violation of this chapter is subject to penalties as set forth in Section 1-4-1 of this code; as such section shall be amended from time to time.*

The system's operator (currently UWO under contract) acts as its "agent" to enforce the cross-connection control ordinance (quoted foregoing).

Cross-Connection Control Program:

1. All connections to the distribution system shall be equipped with backflow prevention assemblies of the type and class required as siren in the table of requirements in IDAPA (Idaho Administrative Rules) 58.01.08.900.02 (Table 2). (Copy included).

2. Each facility requiring such backflow prevention device shall be inspected once a year to verify that all potential cross connections are protected as required. For new connections, required protection must be installed prior to commencing water service.

3. Service shall be discontinued to any facility failing to provide required backflow prevention.

4. Double check valves and/or reduced pressure principle backflow preventers and/or pressure vacuum breakers must pass the pertinent performance test) the University of Southern California Foundation for Cross-Connection Control and Hydraulic Research and meet the American Water Works Association C-510 or C-511 standard.

5. If atmospheric vacuum breakers or pressure vacuum breakers are used, they shall be marked approved by the International Association of Plumbing and Mechanical Officials (IAPMO) or by the American Society of Sanitation Engineers (ASSE).

6. Resilient seated shut off valves shall be used wherever double check valves, reduced pressure backflow prevention assemblies, and/or pressure vacuum breakers are installed.

In its enforcement program, the Operating Contractor implements the requirements of IDAPA 58.01.08-550.07.a:

> All suppliers of water for community water systems shall implement a cross connection control program to prevent the entrance of toxic or hazardous substances to the system. Reference should be made to the AWWA "Cross Connection Control Manual," as specified in Subsection 002.02.n. of these rules. The program will include: (4-6-05)
> i. An inspection once a year of all facilities listed in Subsection 900.02 to locate cross connections and determine required suitable protection. For new connections, suitable protection must be installed prior to providing water service. (5-3-03)
> ii. Required installation and operation of adequate backflow prevention assemblies. A selection chart for various facilities, fixtures, equipment, and uses of water is provided in Subsection 900.02. (4-6-05)
> iii. Annual inspections and testing of all installed backflow prevention assemblies by a tester licensed by a licensing authority recognized by the Department. (4-6-05)
> iv. Discontinuance of service to any facility where suitable backflow protection has not been provided for a cross connection. (12-10-92)
> v. If double check valves and/or reduced pressure principle backflow prevention assemblies and/or pressure vacuum breakers are used, they must pass a performance test conducted by the University of Southern California Foundation for Cross-Connection Control and Hydraulic Research and meet the American Water Works Association C-510 or C-511 standard, or an equivalent standard approved by the Department. (4-6-05)
> vi. If atmospheric vacuum breakers and pressure vacuum breakers are used, they shall be marked approved by the International Association of Plumbing and Mechanical Officials (IAPMO) or by the American Society of Sanitation Engineers (ASSE). (10-1-93)
> vii. Resilient seated shutoff valves shall be used after the effective date of these rules when double check valves, reduced pressure backflow prevention assemblies, and pressure vacuum breakers are installed.(5-3-03)"

APPENDIX K
Emergency Response Plan

APPENDIX K
EMERGENCY RESPONSE PLAN

This system is well-protected by the intertie with United Water Idaho against most causes of emergency, and especially against emergency due to well or pump failure. A pipe rupture in the distribution system might conceivably require interrupting service to a local area until repair was completed, which could potentially be a matter of days. For such an occasion, bottled water could be supplied by any of several firms operating in or near Boise. Advertisers offering "bottled or bulk water" through the local telephone directory include:

- Culligan of SW Idaho, phone 343-1816
- Ecowater Systems/Intermountain Water Company, phone 375-1222
- Idaho Springs Water Company (in Nampa), phone 562-0655
- Sawtooth Water Products, phone 424-6777
- Shadow Mountain Spring Water (Nampa), phone 465-0355
- Waterco, Inc., phone 433-0300

Essential sanitation needs can be met temporarily by portable restrooms, if needed (which would depend on the probable duration of the water service interruption). These can be rented locally from:

- A Company, phone 362-3000
- ABC Sanitation Company, phone 888-2450
- Treasure Valley Toilets, Inc., phone 388-3949

Public Water System
Emergency Response Plan Guide

The Idaho Department of Environmental Quality (DEQ) urges all public drinking water systems to adopt an emergency response plan. Emergency plans are action steps to follow if a primary source of drinking water becomes contaminated or the flow of water is disrupted.

The purpose of this guide is to help you understand and meet the basic standards for an emergency plan. The purpose of an emergency plan is twofold: (1) establish a procedure for the management and staff of a water system to follow in case of an emergency, and (2) help a water system reduce its vulnerability to emergencies. Once you complete your plan, keep it on hand for any unforeseen emergency. Fill in all boxes or circle "yes" or "no" where required.

Important Note: Because this plan may identify certain deficiencies within your system, **access to the plan should be restricted.** Copies should not be provided to any person or agency that you do not work with or know. If you have any questions regarding a request to copy or review your plan, please contact your designated regional DEQ contact.

Section 1. System Identification

Public Water System Number (PWS) Number	4010201	
System Name	City of Eagle Municipal Water System	
Town/City	Eagle	
Source ID Tag Number/Type/Description	Drilling Permit No. 63-91-W-044 No I.D. Tag Present*	
Source ID Tag Number/Type/Description	Drilling Permit No. 63-92-W-170 No I.D. Tag Present*	
Source ID Tag Number/Type/Description		
Population Served and Number of Service Connections	people served: 3692	# of connections 1300
System Owner (the owner must be listed as a person's name)		
Name, title, and telephone number of person responsible for maintaining this emergency plan.	name and title: Michael C. McCurry Facilities Manager	Telephone: 208-939-6813

Section 2. Chain-of-Command

It is important for a water system to have and maintain an up-to-date organizational "chain-of-command" that identifies who is responsible for making decisions during an emergency. **The first response step** in an emergency is to inform the person at the top of your chain-of-command. This will reduce confusion and increase the speed of your response. Your emergency plan should include a chain-of-command flow chart listing names, titles, and day/night telephone numbers of the key people who will be responsible for managing an emergency at your system. Additionally, the system must determine the role of each key person during an emergency. Include with the plan your chain-of-command flow chart and a brief description of each person's responsibilities during an emergency.

Section 3. Notification

It may be necessary to quickly notify other parties during an emergency. Other parties might include your water system users, health department officials, DEQ personnel, and service/repair providers. Please fill out the lists on the next page. The following lists are not intended to be inclusive -- they may be adapted to your specific needs. Include any additional listings that you consider appropriate. The level of effort needed for notification will vary greatly depending on the size of the system and the nature of the emergency. All systems should plan ahead how you will accomplish notification of your customers.

Local Notification List

Fire Department (day telephone number) 939-6463	Fire Department (night telephone number) 911
Police Dept (day) 938-2260	Police Dept (night) 911
Ambulance service (day) 939-6463	Ambulance service (night) 911
Health Department (day) 375-5211	Health Department (night) 375-5211
Water System Operator (day) United Water - 362-1300	Water System Operator (night) 362-1300
Neighboring Water System (day) United Water – 362-1800	Neighboring Water System (night) 362-1300
Neighboring Water System (day) Eagle Water Company – 939-0242	Neighboring Water System (night) 939-0242
Other: ACCEEM 577-4750	Other: 577-4750
Other:	Other:
Other:	Other:

Service/Repair Notification List

Electrician (day telephone number) Bright Ideas - 378-1889	Electrician night (night telephone number) 866-4069
Electric Utility Company (day) Idaho Power - 388-2050	Electric Utility Company (night) 888-2050
Plumber (day) A-1 Plumbing – 472-7277	Plumber (night) 472-7277
Pump Specialist (day) Burgess – 939-6603	Pump Specialist (night) 573-6068
Soil Excavator (day) John Sawyer Excavation – 941-2882	Soil Excavator (night) 939-2585
Equipment Rental (day) Tates Rents – 939-1555	Equipment Rental (night) 939-1555
Other:	Other:
Other:	Other:
Other:	Other:

State Notification List

Idaho Com Center (24 hours a day, 7 days a week). Only call the Com Center if you believe that there is a suspected or intentional contamination or intrusion into your system. -see **"When to call the Com Center"** on the next page.* Call the Com Center at **1-800-632-8000.** If that number is busy, call the **alternative** Com Center telephone **number: 1-208-846-7610.** *Specify that your call concerns a threat to a drinking water system.*	
Local Regional Department of Environmental Quality (DEQ) Office (day telephone number): 373-0550	Local Regional Department of Environmental Quality (DEQ) Office (night telephone number): 373-0550
Local Department of Health (day telephone number) 334-5939	Local Department of Health (night telephone number) 334-5939
Other:	Other:
Other:	Other:

*** When to Call the Com Center**
You should call when your system may have experienced any of the following scenarios:

- Physical security is compromised or there is obvious evidence of accidental or malicious intrusion.
- There is evidence of vandalism that may suggest intrusion leading to an added vulnerability of the system (e.g., hole in fences or gates, barbed wire cut, locksets removed or destroyed, etc.).
- Suspicious materials have been found around a site which is part of, or associated with, a public water supply (e.g., discarded packaging, plastic bags, unlabeled and discarded containers, evidence of marks indicating devices were dragged across the ground, vehicle tracks, etc.).
- An anonymous threat is directed at a location or facility.

Notification Questions

Does this system have a specific location(s) where up-to-date notification information, including telephone numbers of key officials and services, is kept at all times?	☒ Yes	☐ No
Are the key decision-makers of this system clearly aware of where to find this information quickly?	☒ Yes	☐ No
Are the key decision-makers of this system familiar with your notification procedures?	☒ Yes	☐ No
If you checked "no" for line 1, 2, or 3, when will the situation be corrected?		

System Users with Special Water Needs
In an emergency your water system may have to provide priority notification to users with unique or special water needs. Unique or special users would include nursing homes, elderly housing facilities, hospitals, or individuals with serious medical concerns or mobility limitations. Water systems must identify and maintain an up-to-date list of service customers with unique water needs and make provisions for safe and adequate water supply to them.

Remember to take into consideration other special water needs such as fire protection. Fire departments must have quick access to water in times of emergency in order to protect the public. Develop a plan of action with your local fire department.

Does this system have service customers with unique water needs?	☐ Yes	☒ No

If you checked "Yes" above for "service customers with unique water needs," make a list of unique service customers and a brief description of how you will notify them and provide for their water needs.

Section 4. System Components

It is essential that a water system have accurate up-to-date information about its facilities such as supply and storage, system plans, hydraulic connections, and system storage and production demand. This information will help make repairs easier in case of an emergency, and will also be valuable in assessing system vulnerability in an emergency.

System Plan
Attach an up-to-date, accurate, plan of your system that shows at least the locations of all individual wells (active and inactive), pump stations, water treatment facilities, storage tanks, distribution lines, and key shutoff points for isolating sections of your distribution system. Attach a brief discussion of this system's ability to isolate sections of the distribution system.

System Supply and Storage
Attach an up-to-date list of your system's primary features. List at least each active well, each operable inactive well, total production capacity of each active and operable inactive well, each storage tank, capacity of

each storage tank, each treatment facility, and each pump station. If you have an atmospheric storage tank(s), indicate whether or not it is equipped with a capped and lockable fill pipe to accommodate tank truck water delivery.

Does this system have an atmospheric storage tank? If yes, how many?	☐ Yes	☒ No	# tanks:
Are your atmospheric storage tank(s) equipped with a fill pipe for supplied water?	☐ Yes	☐ No	☒ N/A

Hydraulic Connection between Sources

A contamination event may not impact all of your production wells. However, contamination in one well could affect another well if they are hydraulically connected, i.e., contaminated water is drawn into an uncontaminated well when it is pumped. Knowing the hydraulic connection between your production wells (if any) enables you to assess the extent that contamination in any single well will impact your total production capacity. If pumping a single well results in drawdown in other wells, hydraulic connection exists between those wells. Pumping rates can also influence hydraulic connection. Attach a description of the hydraulic connection between your producing wells. A detailed hydrologic evaluation is not necessary; you may base your description on existing information.

System Demand

During an emergency, a water system may need to reduce its demand or use its excess capacity to continue to provide safe water to its users. Write out how your system could use demand reduction and excess capacity during an emergency. Please answer the following questions.

What is the total production capacity of this system?	1,224,000 gallons per day
What is the total storage capacity of this system?	0 gallons
What is the average daily demand of this system?	350,000 gallons per day
What is the maximum daily demand of this system?	891,000 gallons per day
Divide total storage capacity by average daily demand.	0 days

Section 5. Boil Water Notification

An emergency could create the potential that your well or source has been contaminated with microbiologic pathogens. The presence of certain pathogens in drinking water is a significant health concern. If that happens it may be necessary to implement a boil water notification. Include a brief description of how this system would implement a boil water notification. Contact your regional DEQ office for guidance on boil water notification. Keep an e-mail list or a telephone list of your customers and public establishments on hand for quick notification.

Section 6. Alternative Water Source

An emergency may necessitate obtaining water from an outside source to meet your basic water needs. All public water systems should plan ahead how they will provide alternative safe water during an emergency. Develop your system's contingency plan for providing alternative water considering bottled water, bulk water, and new or other sources.

Have you discussed your potential water needs with at least 2 suppliers?	☒ Yes	☐ No
Approximately how long will it take for bottled or bulk water to reach this system?	See attached hours	

Bulk Water
A list of suppliers of bulk water haulers may be found on the DEQ web site - **see list of "Certified Idaho Bulk Water Haulers" on DEQ's Web site at** http://www.deq.state.id.us/water/water1.htm - drinking_water.

New Source of Water
An emergency may necessitate that your system develop a new source of water or use an inactive source. Remember - contact your local regional DEQ office or local health district for prior approval of new sources of water or the use of inactive sources. If your alternative water plan includes using an inactive source, you may have to consider your treatment capabilities.

Tie-in to Adjacent Water Supply System
Some water systems are situated in close proximity to one or more other water systems.

Are any water systems situated adjacent to this system?	☒ Yes	☐ No
Have you discussed the feasibility of connecting to another system with representatives of that system(s)?	☒ Yes	☐ No
Is it feasible for this system to connect to an adjacent system? If yes, how you would make the connection?	☒ Yes	☐ No

Section 7. Water Conservation

Water conservation can be an effective means of coping with minor losses of source capacity. Describe how your system would use conservation measures during an emergency. Your assessment should examine the potential of this system to save significant quantities of water through conservation measures, and a priority list of categories of water use that are nonessential in times of water shortage.

Section 8. Vulnerability Assessment (See the Idaho Drinking Water Newsletter #29 for information and deadlines for vulnerability assessments as outlined in the 2002 Bioterrorism Act.)"

We encourage you to consider conducting a vulnerability assessment of your system as a valuable management/planning tool for your system. A vulnerability assessment looks for the "weak link in the chain" and frequently those weak areas can lead to emergencies. Some causes of emergencies are preventable.

Consider some of the following areas in your assessment. Age and obsolescence of equipment, poor maintenance, poor system design, lack of spare parts, high risk or ill advised land usage near a water source, and lack of source protection efforts are all preventable factors that can cause water system emergencies. Reducing a system's vulnerability to an emergency is a vital part of any emergency plan.

List and briefly describe any vulnerable areas of your system that need correction or improvement. Consider each supply, storage, and distribution component of your system when you do this, being sure to include each of the primary features of your system that were listed in Section 4, System Components. Also, consider the land usage near your water source(s) when you describe your vulnerable areas. High-risk land usage near your water source(s) may be preventable through source protection measures.

At this time, does this system have any vulnerable component areas that need correction or improvement?	☒ Yes	☐ No
At this time, does this system have any land usage concerns that could be minimized through source protection measures?	☐ Yes	☒ No
Has this system received its Source Water Assessment Report from the DEQ? If so, you should refer to this report when compiling your vulnerability assessment.	☒ Yes	☐ No

Section 9. Plan Readiness

In order for this plan to be useful, those people involved with the system must know the plan exists, they must know where to quickly find the plan, and they must understand their role during an emergency.

Do the key representatives of this system know about this emergency plan?	☒ Yes	☐ No	
Has this system clearly defined for each key person what his or her responsibilities will be during an emergency, i.e., does each key person clearly understand their role?	☒ Yes	☐ No	
Has this system rehearsed this emergency plan within the last two years?	☒ Yes	☐ No	
For property owner associations: will each successive group of officers be informed of the existence of, and briefed on, all aspects of this emergency plan?	☐ Yes	☐ No	☒ N/A

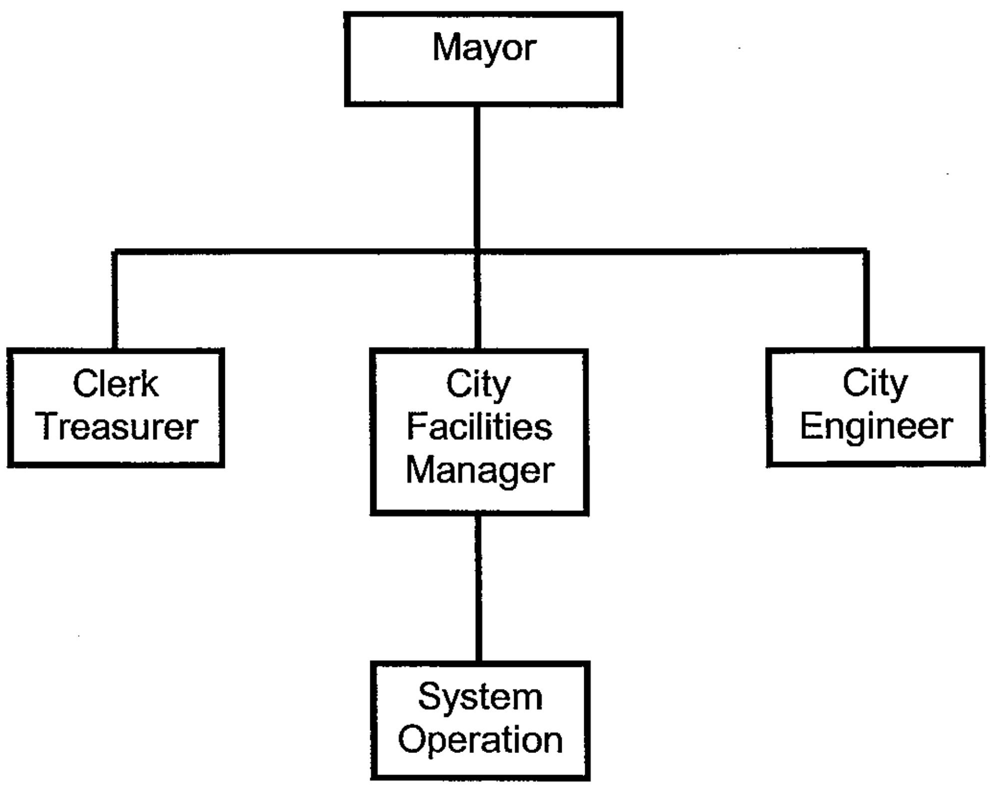
Section 10. Signatures

For the record, have representatives of this water system who helped complete this emergency plan sign and date below.

Sharon K Bergmann, City Clerk system representative/title: Michael C. McCurry, Facilities Manager	10-31-05 date:
Kenneth R. Rice system representative/title: Kenneth R. Rice, P.E., Project Engineer	10/27/2005 date:
Nancy E Merrill system representative/title: Honorable Nancy E. Merrill, Mayor, City of Eagle	10/31/2005 date:

EAGLE MUNICIPAL WATER SYSTEM
ATTACHMENTS
EMERGENCY RESPONSE PLAN

Section 2
Chain of Command
Table of Organization
City of Eagle
Municipal Water System



ATTACHED RESPONSES
EMERGENCY RESPONSE PLAN
CITY OF EAGLE
MUNICIPALLY OWNED WATER SYSTEM

Page 1

Section 1. System Identification = Wells were completed in 1991 and 1992. ID tag system was started in 1997.

Section 2: Chain of Command – See attached Table of Organization

Section 3: Features List –

Well No. 1 - 250 GPM pump & VFD control
600 GPM pump & VFD control
RTV connection to UWI op center
Chemical injections of chlorine polyphos

Well No. 2 - (Inactive) Single pump
Line start
Intertie valves & PRV's

Page 3

Section 4: System Plan – See attached map

Page 4

Section 5: Boil Water Notification –

"Boil Water" notification, if needed, would be announced on local news media, school administration and Home Owner's Association officers would be notified by telephone and notice would be posted at City Hall.

Section 6: Alternative Water Source –

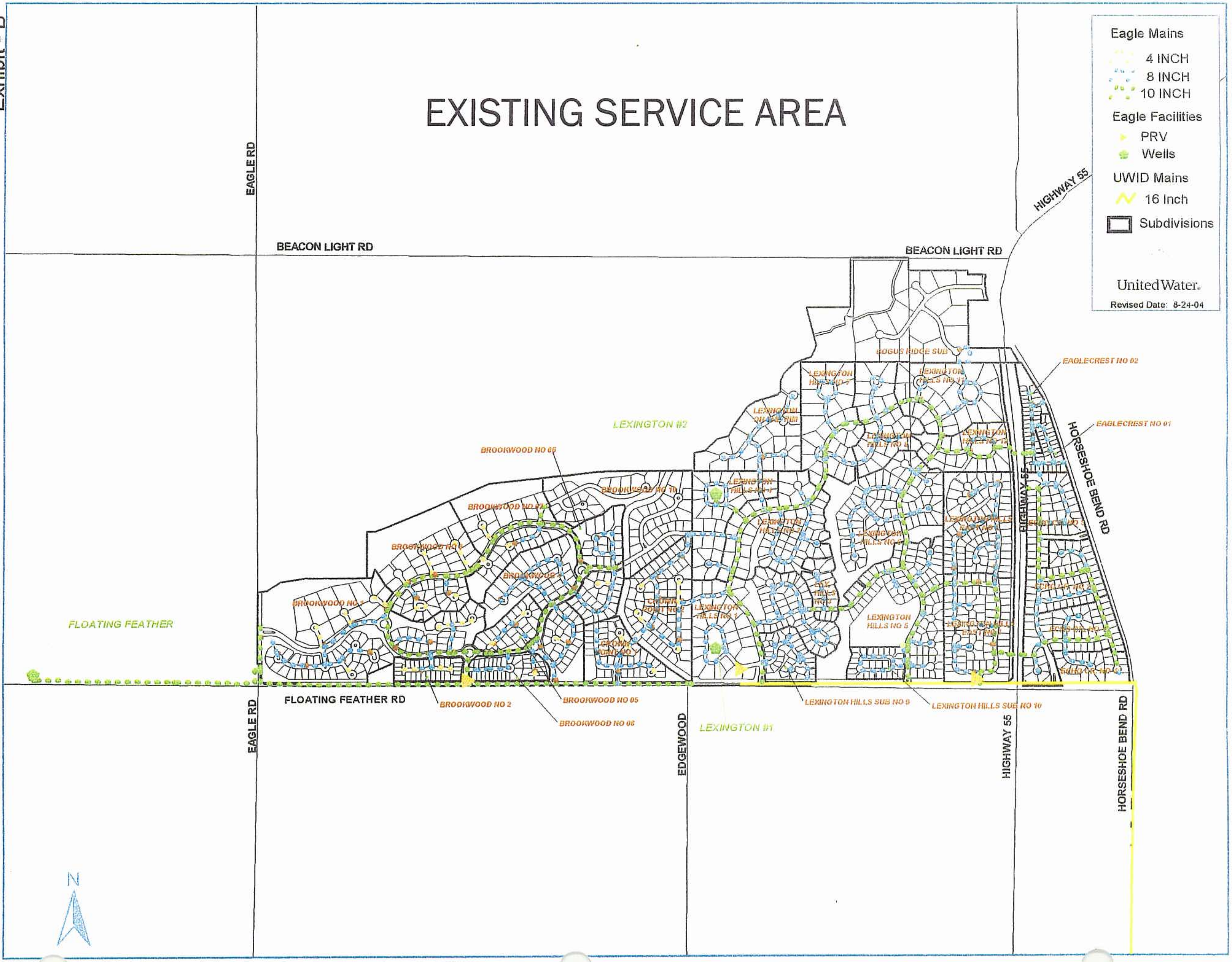
Bulk water could reach system in approximately two hours, but since the system is intertied with UWI, there is very little chance that bulk haul would ever be needed.

Bottled water is available with a delivery time of one hour or less. Grocery stores carrying bottled water make small quantities available even more quickly.

Section 7: Water Conservation –

Conservation measures are unlikely to be necessitated by emergency due to the high delivery capacity of the intertie with United Water. If conservation is required, notification means would be by local news media, notification to school officials and Home Owner's Associations and posting at City Hall.

Exhibit - B



EXISTING SERVICE AREA
Eagle Mains
4 INCH
8 INCH
10 INCH
Eagle Facilities
PRV
Wells
UWID Mains
16 Inch
Subdivisions
United Water
Revised Date: 8-24-04
EAGLE RD
BEACON LIGHT RD
BEACON LIGHT RD
HIGHWAY 55
HORSESHOE BEND RD
FLOATING FEATHER RD
EDGEWOOD
HIGHWAY 55
HORSESHOE BEND RD
EAGLE RD
LEXINGTON #2
LEXINGTON #1
FLOATING FEATHER
BROOKWOOD NO 2
BROOKWOOD NO 05
BROOKWOOD NO 06
LEXINGTON HILLS SUB NO 9
LEXINGTON HILLS SUB NO 10
EAGLECREST NO 02
EAGLECREST NO 01
LEXINGTON HILLS NO 5
N

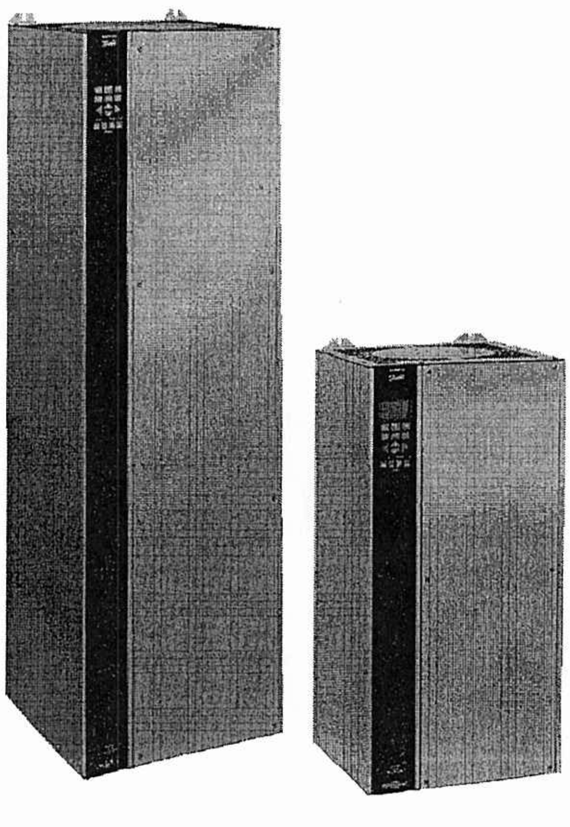
APPENDIX L
Manufacturers' Maintenance Manuals

- ♦ Danfoss – VFD unit for 75 hp pump
- ♦ Danfoss – VFD unit for 30 hp pump
- ♦ CLA-VAL – Automatic Control Valves
- ♦ ABB – Master Meter
- ♦ Waterous

Drives and Controls

Danfoss

Service



VLT® 5060-5250 Series Service Instructions

Table of Contents

Section V Disassembly

5060-5100 Nema 12 / IP54

5060-5100 Chassis / Nema 1 / IP20

5125-5150 Nema 12 / IP54

5125-5150 Chassis / Nema 1/ IP20

INTRODUCTION

The purpose of this manual is to provide technical information and instructions that will enable the user to identify faults and perform repairs on the VLT 5000, VLT 5000 AQUA and the VLT 6000 series Adjustable Fequency Drives models VLT 5060-5250, VLT 5075-5300 AQUA and VLT 6075-6275.

This manual has been divided into five sections. The first section covers the description and sequence of operations. Section two covers fault messages, troubleshooting charts, and application specific information. Section and four describe the various tests and methods used to evaluate the drives condition. Section five covers the removal and replacement of the various components.

VLT® PRODUCT OVERVIEW

The VLT 5000, 5000 AQUA and the 6000 Series inverters are available in power sizes from 1Hp - 600Hp in the 380 - 460V range and 1 - 60Hp in the 200V range. This manual covers the VLT 5000 60-250Hp, VLT 5000 AQUA 75-300Hp and VLT 6000 75-300Hp all in the 380-460V range.

These models are available in Chassis, NEMA 1 or NEMA 12 enclosures.

The VLT 5000 series units are programmable for either constant or variable torque operation. There are three hardware configurations available for all sizes of drives, they are: Standard (ST), Standard with Brake (SB), and Extended with Brake (EB).

The SB and EB units contain all logic and hardware necessary to connect an external resistor to provide dynamic braking.

The EB configuration offers connection terminals for load sharing capabilities between multiple VLT 5000 Series units, plus input terminals for a remote 24 VDC power supply to maintain control logic during removal of the AC input power.

The VLT 5000 AQUA is designed primarily for the water industry for control of variable torque pumping applications. It is available with the same enclosure possibilities as its 5000 series counterpart but without the choice of hardware configurations. The VLT 5000 AQUA has specific advantages over the VLT 5000 series in variable torque applications and can only be used for such loads.

The VLT 6000 series is designed primarily for the HVAC industry for control of variable torque fan and pump applications. It is available with the same enclosure possibilities as its 5000 series counterparts but has specific advantages over the VLT 5000 series in HVAC applications and can only be used on variable torque loads.

WARNING:

The VFD contains dangerous voltages when connected to the line voltage. Only a competent technician should carry out the service.

FOR YOUR SAFETY:

1) DO NOT touch the electrical parts of the AFD when the AC line is connected. After the AC line is disconnected wait at least 15 minutes before touching any of the components.

2) When repair or inspection is made the AC line must be disconnected.

3) The STOP key on the control panel does not disconnect the AC line.

4) During operation and programming of the parameters **the motor may start without warning.** Activate the STOP key when changing data.

CAUTION:

Electrostatic discharge (ESD)- Many electronic components are sensitive to static electricity. Voltages so low that they cannot be felt, seen or heard can reduce the life, affect performance, or completely destroy sensitive electronic components.

When performing service, proper ESD equipment should be used to prevent possible damage from occurring.

SECTION ONE

DESCRIPTION OF OPERATION

It is not the intention of this manual to enter into a detailed description of the unit's operation. Moreover, it is intended to provide the reader with a general view of the unit's main assemblies. With this information, the repair technician should have a better understanding of the unit's operation and therefore aid in the troubleshooting process.

The VLT 5060-5250, VLT 5075-5300 AQUA and the VLT 6075-6275 series units are very similar in construction and design. For the purpose of troubleshooting two main differences exist: First, the control card and LCP for the 5060-5250 differ from that of the VLT 5000 AQUA and 6000 series. Second, the rating of the power section is sized differently in a constant torque drive versus a variable torque drive. For example the power section of a VLT 5075 AQUA and VLT 6075 would be similar to that of a VLT 5000 series 60HP (VLT5060). To simplify the discussion we will always refer to the constant torque drives (VLT 5060-5250).

The VLT is divided primarily into three sections commonly referred to as: logic, power, and interface.

LOGIC SECTION

The control card, Figure 1, contains the majority of the logic section. The heart of the control card is a microprocessor which controls and supervises all functions of the unit's operation. In addition, separate PROM's contain parameter sets which characterize the unit and provide the user with the definable data enabling the unit to be adjusted to meet the customers specific application requirements. This data is then stored in an EEPROM which provides security during power-down and also allows flexibility for future changes as needed. A custom integrated circuit generates the PWM waveform which is then sent on to the interface circuitry located on the Power Card.

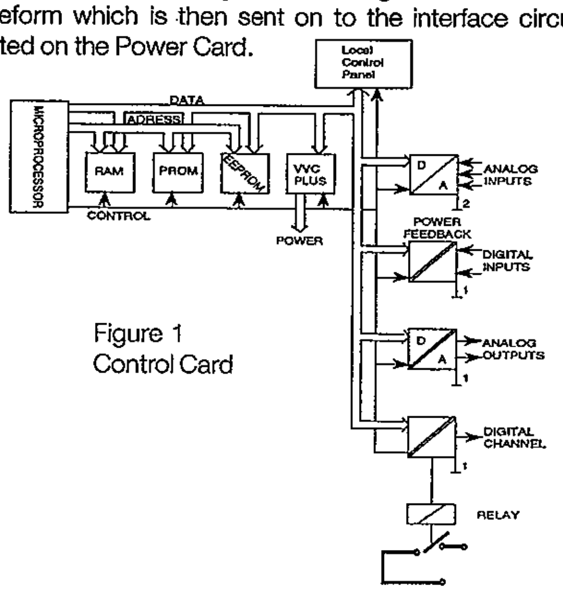


Figure 1
Control Card

The PWM waveform is created using an improved control scheme called VVC^plus, which is a further development of the VVC (Voltage Vector Control) system used in the VLT 3000 Series. VVC^plus provides a variable frequency and voltage to the motor in such a way that it matches the requirements of the motor. The dynamic response of the system is such that it changes to meet the changing requirements of the load.

Also, part of the logic section is the LCP (Local Control Panel). This is a removable keypad/display mounted on the front of the unit. The keypad or the MMI (Man/Machine Interface) provides the interface between the digital logic and the human programmer.

In addition, The LCP can be removed during operation to prevent undesired program changes. The final shared program of the drive can be also uploaded into the EEPROM at the LCP. This function can be helpful in programming multiple drives or if needed to restore a program to a repaired unit. With the addition of a remote mounting kit, the LCP can be mounted in a remote location of up to three meters away.

A series of customer accessible terminals are provided for the input of such commands as: Run, Stop, Forward, Reverse and Speed reference. Terminals are also provided to supply output signals to peripheral devices for the purpose of monitoring and control.

In addition, the control card is capable of communicating via serial link with outside devices such as personal computers or programmable logic controllers.

The control card provides two voltage supplies for use from the customer terminal strip. The 24VDC is used for switching functions such as: Start, Stop and Forward/Reverse. The 24VDC supply is capable of supplying 200ma of power, part of which may be used to power external devices such as encoders. A 10VDC supply rated at 17ma is also available for use with speed reference circuitry.

The analog and digital output signals are powered through a third non customer accessible supply.

All three power supplies are isolated from one another to eliminate ground loop problems in the control input circuitry.

A single pole low voltage relay is provided on the control card for the purpose of activating external devices based on the status of the drive. The contacts of the control card relay are rated for 50VAC at 1Amp. However, in UL applications the rating is limited to 30VDC at 1Amp.

Provisions have been made on the control card assembly for the addition of option modules such as: synchronizing control, serial communication options, additional relays, cascade controller option or custom operating software.

LOGIC TO POWER INTERFACE

The Logic to Power Interface isolates the high voltage components of the power section from the low voltage signals of the Logic Section. This is accomplished on the Power Card. All communication between the control logic and the rest of the unit passes through the Power Card. This communication includes: DC bus voltage monitoring, line voltage monitoring, output current monitoring, temperature sensing, inrush control and the gate drive firing signals.

The Power Card also contains a Switch Mode Power Supply (SMPS) which provides the unit with 24VDC, +14VDC, -14VDC and 5VDC operating supplies. All logic and interface circuitry is powered by the SMPS. Normally the SMPS is fed by the DC bus voltage, however, in the Extended version of the drive, it is possible to power it with an external 24VDC power supply. This enables operation of the logic circuitry without the power section being energized. Circuitry for controlling the cooling fan power auto transformer is also provided on the Power Card.

In units with Dynamic Brake options, the logic and firing circuitry for the brake operation are also contained on the Power Card.

In addition to passing the communication pertaining to output current to the control logic, much of the fault processing of output short circuit and ground fault conditions is done on the Power Card. A custom IC called an Application Specific Integrated Circuit (ASIC) continually monitors output current conditions with respect to: peak amplitude, rate of rise (di/dt) and leakage current (ground fault). At the point that any of these conditions are considered critical, the gate drive signals are immediately shut-off and an alarm signal is sent to the control logic for displaying the fault information.

Also located on the Power Card is a second relay for monitoring the status of the VLT 5000. The relay is Form C, meaning it has one normally open contact and one normally closed contact on a single throw. The contacts of the relay are rated for a maximum load of 240VAC at 2Amps.

POWER SECTION

The Power Section, Figure 2, contains the Soft Charge Circuitry, SCR/Diode modules (rectifier), the DC Bus Filter Circuitry, often referred to as the Intermediate Circuit, Motor Coils, and the Output IGBT (Isolated Gate Bipolar Transistor) modules which make up the Inverter Section.

In conjunction with the SCR/Diode modules the soft charge circuit limits the inrush current when power is first applied and the DC bus capacitors are charging. This is accomplished by the SCR's in the modules being held off while charging current passes through the soft charge resistors, thereby limiting the current. The DC bus circuitry smooths the pulsating DC voltage created by the conversion from the AC supply. The number of DC bus capacitors will vary depending on the drive size with the VLT 5250 having the most at 20. The DC coil is a single unit with two coils wound on a common core. One coil is placed in the positive side of the bus and the other in the negative. The DC coil serves to aid in the reduction of line harmonics.

The inverter section is made up of six IGBT's commonly referred to as switches. It is necessary to have one switch for each half phase or a total of six. These six IGBT's may be found incorporated into various packages. In vary small units, typically under 10Hp, all six IGBT's will be in a single module called six-packs. In the VLT 5060 - 5100 two switches are contained in a single module, called a dual pack, for a total of three and in VLT 5125 - 5250 each switch is in a single module for a total of six modules in all.

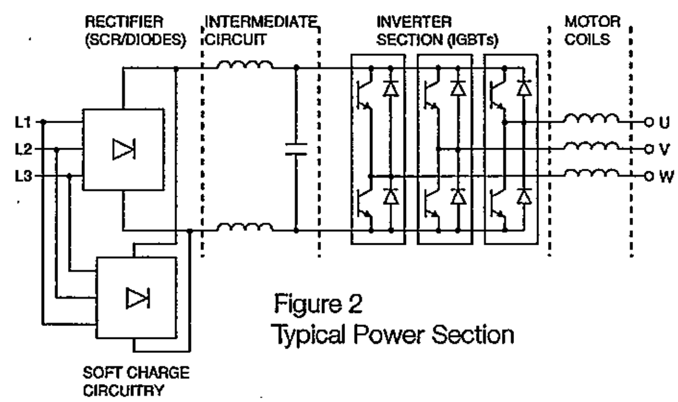


Figure 2
Typical Power Section

The Motor Coils serve to provide a limit to the rate of current rise (di/dt) during peak demands of the output. They serve their greatest purpose during the high and fast rising currents experienced during ground faults or short circuits on the output. The Motor Coil is a single assembly with three coils wound on a common core.

SEQUENCE OF OPERATION

(Also refer to the full block diagrams in the appendix)

Soft Charge Section

When input power is first applied, Figure 3, it enters the VLT through the RFI option if the unit is so equipped. The SCR's in the combined SCR/Diode modules are not gated so current travels down and through the soft charge fuses to the soft charge rectifier, BR1. Three phase power is also branched off and sent to the Power Card. It only serves the power card a reference of the main supply voltage.

During the charging process the top diodes of the soft charge rectifier conduct and rectify during the positive half cycle. The diodes in the main rectifier conduct during the negative half cycle. The DC voltage is applied to the bus capacitors through F4, the soft charge resistor fuse, and R1, the soft charge resistor. In units of 150Hp and up, two soft charge resistors and fuses are placed in parallel.

The purpose of charging the DC bus through these resistors is to limit the high inrush current that would otherwise be present.

A thermal switch, SW1, is mounted on each soft charge resistor. Should the resistor overheat due to repeated power cycling or a problem in the DC bus circuit the thermal switch will close causing F4, the soft charge resistor fuse, to blow thereby opening the charging circuit.

The Metal Oxide Varistor (MOV), MOV1, serves to protect the soft charge rectifier from transients. R2 and C1 in conjunction with the lower diodes in the soft charge rectifier serve as a snubber network for the SCR/Diode modules. The additional resistor, R13, provides a return path for current flow should the thermal switch, SW1, close.

Once the charging process is completed and the DC bus reaches an acceptable level the Power Card will begin sending gate signals to the SCR/Diode modules, these gate signals will fire at every zero crossing of the input voltage waveform. The SCR/Diode module will then act as a typical uncontrolled rectifier. Phase angle firing of the SCR's is not used in this configuration. The SCR's are on full at each firing.

At this point the DC bus capacitors are fully charged. The DC bus voltage will be approximately 650VDC when the VLT is connected to a nominal 460VAC supply line. This voltage is now present in the inverter section. This same DC voltage is also delivered to the Power Card to operate the Switch Mode Power Supply (SMPS) which in turn provides all the low voltage supplies used by the Power and Control Cards.

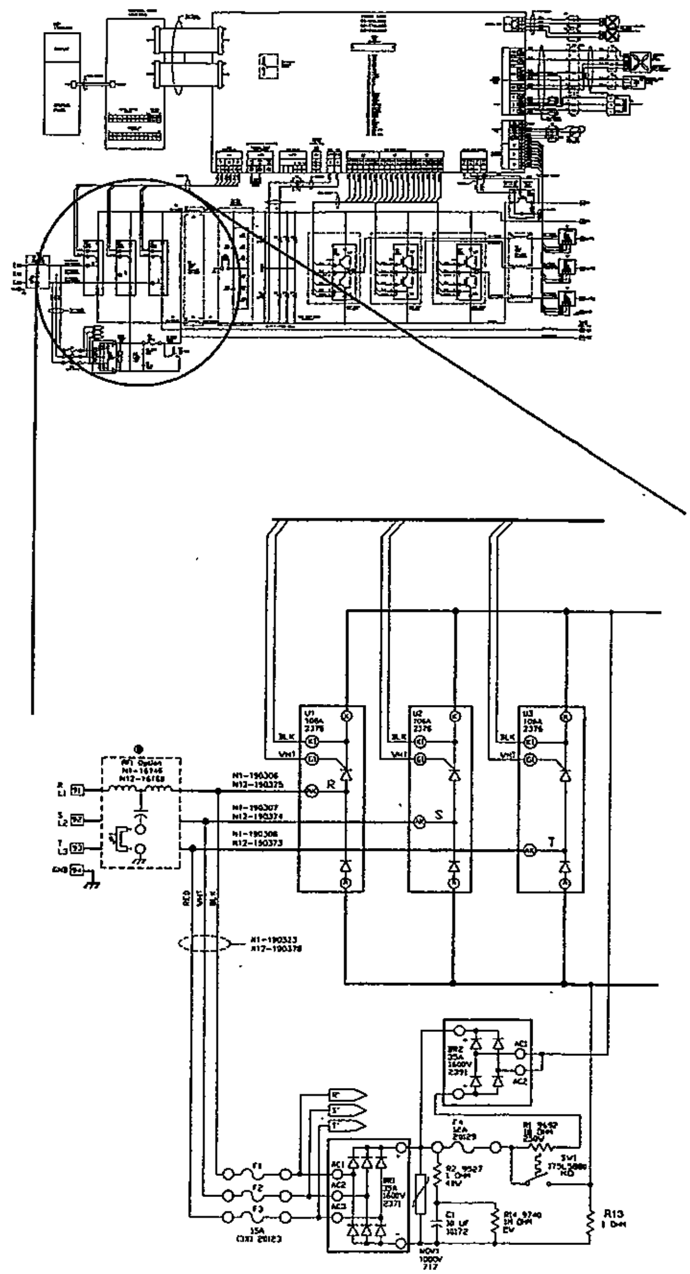


Figure 3
Soft Charge Circuit

Intermediate Section

Moving left to right in the drawing we come to the Intermediate Section, Figure 4. Shown first is the DC Bus Inductor, next is the RFI DC Bus Filter if the unit is equipped with the RFI Option. Notice the jumper to earth ground, this jumper is attached to the Printed Circuit Card which is physically placed at the bottom of the DC Capacitor Bank. This drawing represents a VLT 5075. So, six DC bus capacitors are present, connected in a series parallel configuration. Resistors R4 and R5 are balance resistors for the capacitor bank and also serve to bleed off the bus voltage after input power is removed. Due to the size of the capacitor bank in relation to the resistors it can take up to 15 minutes before the voltage on the capacitors is fully discharged.

(Also refer to the full block diagrams in the appendix Pages 65-78)

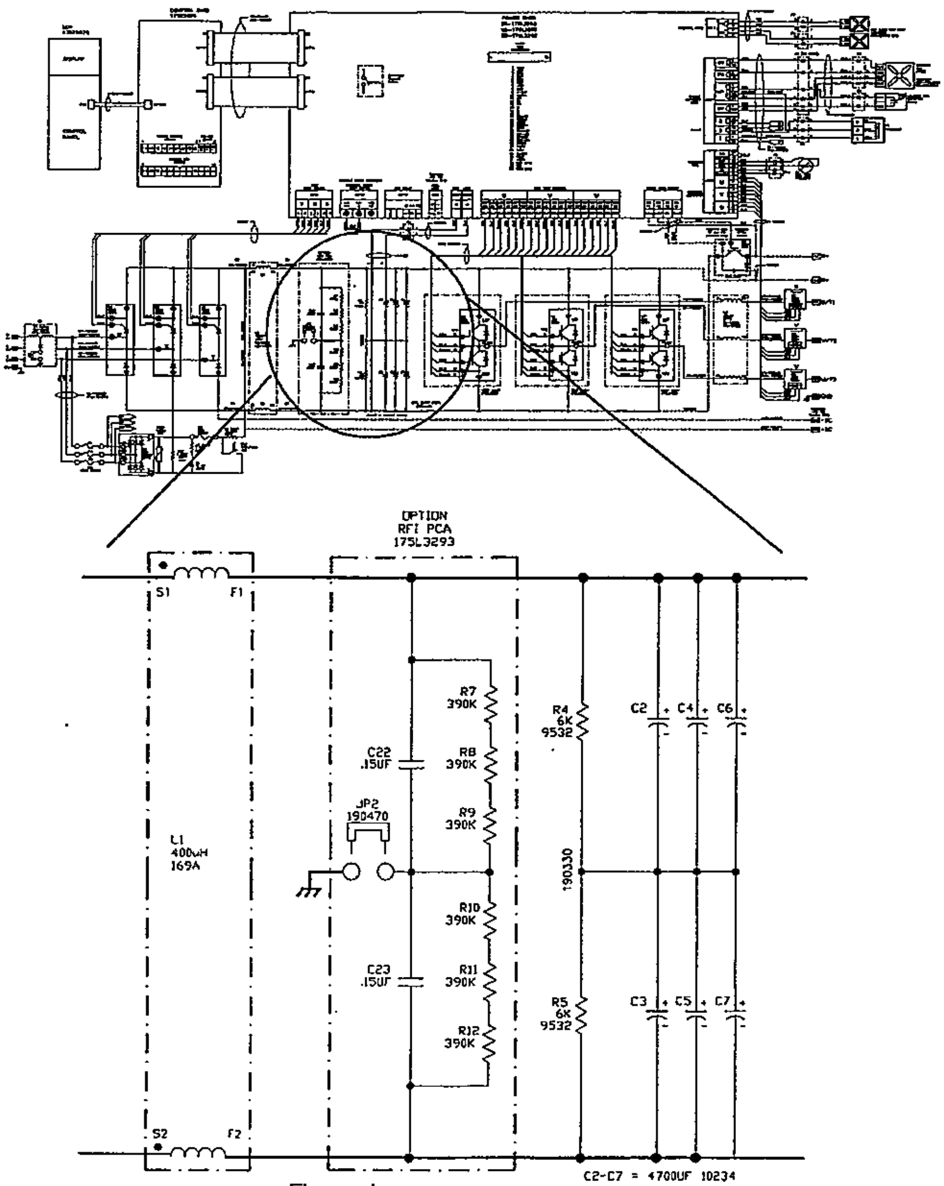


Figure 4
Intermediate Section

Inverter Section

As we reach the Inverter Section, Figure 5. Six IGBT's are packaged in three modules. Gate signals are delivered from the Control Card, through the Power Card and to the gates of the IGBT's. The series connection of each set of IGBT's is delivered to the output, first passing through the output motor coil and the current senors.

The current sensors are hall effect devices which monitor the output current and deliver a proportional signal to the Power Card. These current signals are used by the Control card to determine proper waveform compensations based on load conditions. They further serve to detect over current conditions including ground faults and phase to phase shorts on the output.

(Also refer to the full block diagrams in the appendix Pages 65-78)

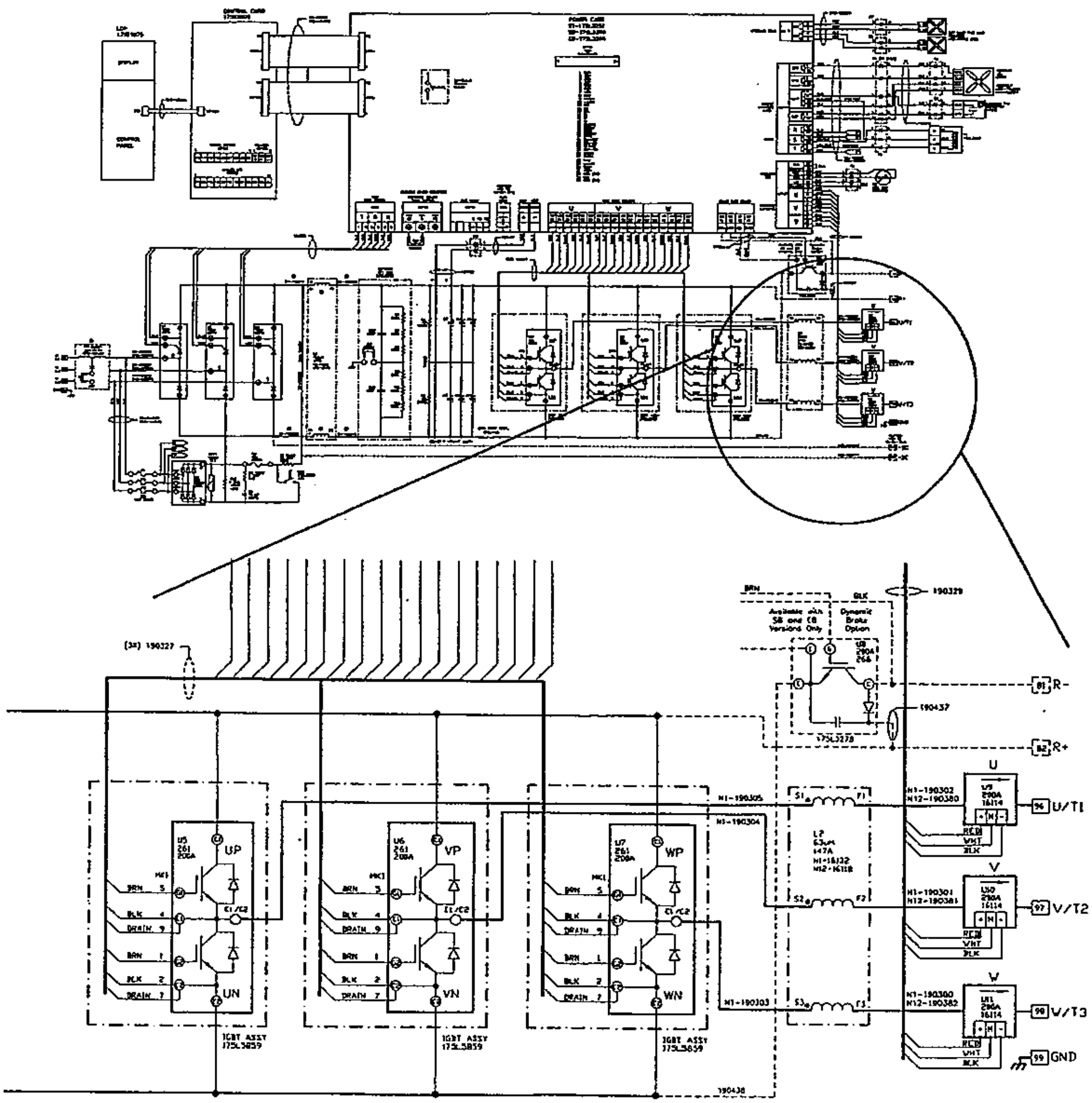


Figure 5
Inverter Section

Once a run command and speed reference are present the IGBT's begin switching to create the output waveform, Figure 6. Looking at the phase to phase voltage waveform with an osilliscope. It can be seen that the Pulse Width Modulation (PWM) principal creates a series of pulses which vary in width. Basically the pulses are narrower as zero crossing is neared and wider the farther you move away from zero crossing. The resultant current waveform, as shown, replicates a true AC sine wave.

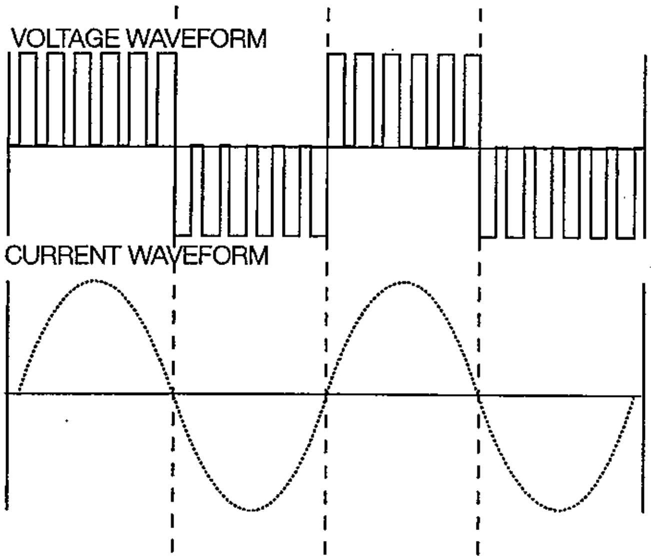


Figure 6

Output voltage & current waveforms

This waveform as generated by the Danfoss VVC^{plus} PWM principle provides optimal performance and minimal losses in the motor.

During normal operation the Power Card and Control Card are monitoring various functions within the VLT. The current sensors are providing current feedback information, the DC bus voltage and AC line voltage are monitored as well as the voltage delivered to the motor. A thermal sensor mounted on the heatsink, Power Card and cap bank (N12 only-5125-5250) provide temperature feedback.

BRAKE OPTION

The optional Brake is available only on SB and EB models. The function of the Brake IGBT, Figure 7, is to switch an externally mounted resistor bank across the DC bus to remove excess DC voltage present on the bus capacitors. Excess DC bus voltage is generally a result of an overhauling load causing regenerative energy to be returned to the DC bus.

The Brake IGBT gate signal originates on the Control Card and is delivered to the Brake IGBT via the Power Card. Additionally the Power and Control Card monitor the Brake IGBT and brake resistor connection for short circuits and overloads.

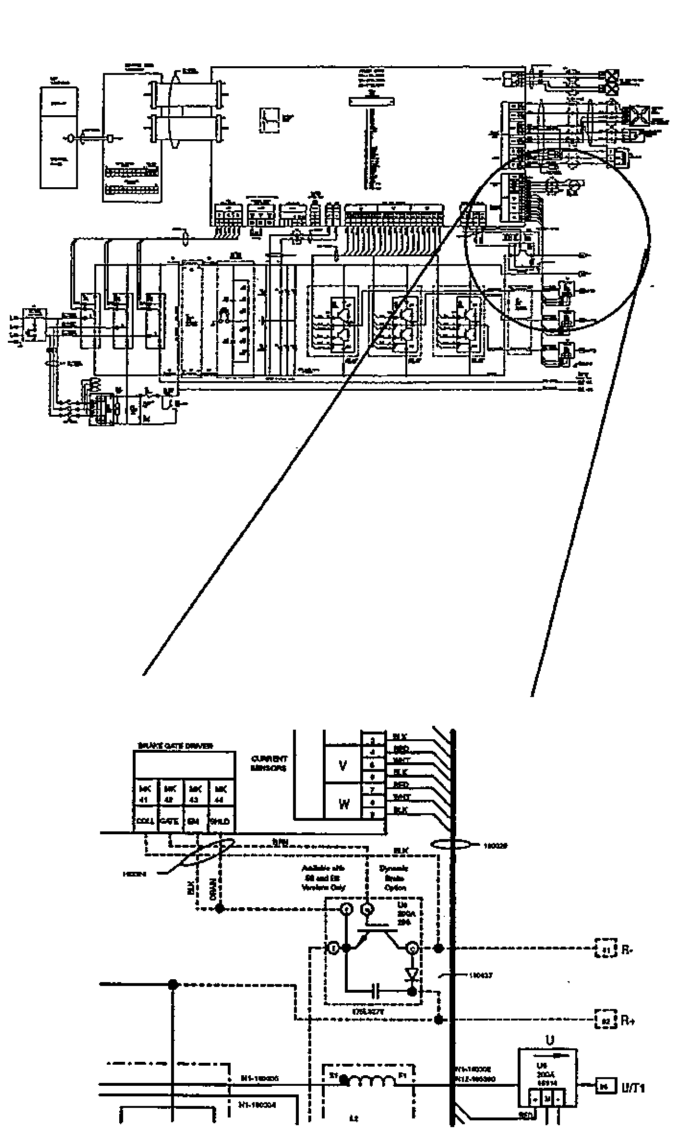


Figure 7
Brake IGBT

COOLING FANS

Various fans are incorporated in the unit. All VLT 's in this size range are equipped with a heatsink fan. In Chassis and NEMA 1 units this fan is mounted on the top of the unit. In NEMA 12 units the fan is mounted below the heatsink in the bottom of the unit. The VLT 5125 - 5250 NEMA 12 units are also equipped with door fans. As the VLT 5060 - 5100 NEMA 12 units are built without door fans they further incorporate capacitor bank fans mounted internally to the DC capacitor bank.

All fans, except the capacitor bank fans which are 24VDC, are powered from an auto transformer that provides 230VAC. On/Off and High/Low speed control of the 230VAC fans is provided in an effort to reduce overall acoustical noise and extend the life of the fans.

FAN CONTROL

Regardless of heatsink temperature, the fans are started shortly after main input power is applied to the VLT. If the heatsink temperature is below 30°C the fans will turn off after a short interval. At a heatsink temperature of >45°C, the fans will be switched on at low speed. This will equate to approximately 165VAC applied to the fans. At a heatsink temperature of >60°C, full voltage is applied to the fans to obtain full speed. When the heatsink temperature returns to <55°C the fans return to low speed an if the heatsink temperature should drop below 30°C, the fans will be switched off.

Since the internal ambient temperature is maintained by one or more 230VAC fans, the transition between low and high speeds can also be made if the internal ambient rises, regardless of heatsink temperature. The internal ambient temperature sensor is located on the power card. If the temperature detected rises to >65°C, the fans will switch to high speed regardless of heatsink temperature. If the internal ambient temperature returns to <50°C and the heatsink temperature remains below 60°C, the fans will return to low speed.

The fans will be switched to high speed should a heatsink over temperature trip occur. Any other temperature trip; internal ambient, output inductor or external disable will result in the fans running at low speed. For further tests, Reference Fan Test on page 29 or the Signal Board in Appendix III.

SPECIFIC POWER CARD CONNECTORS

Connector MK10 on the Power Card provides for the connection of an external temperature switch. It is assumed that such a switch could be used to monitor the temperature of an external brake resistor. Should the switch change states the VLT would trip on a thermal overload and the SCR's as part of the SCR/Diode modules would be disabled.

Connector MK15 provides access to Relay 01 which is mounted on the Power Card. This relay provides a status of the VLT based on the programming of Parameter 323.

A Signal Board is provided for accessing various signals which could be useful in troubleshooting the VLT . An adapter card with test points is available for ease of connection. For a further description of the Signal Board outputs see Appendix III.

Only available on EB type units is connector MK4. This connection allows for the input of an external 24VDC power supply. When connected, a secondary SMPS is powered which enables the Control Card functions to remain active even after the removal of the main supply. The VLT can be run from this power supply however, the IGBT's will not be switched on during this mode.

LOAD SHARING

NOTE: By using the load sharing option of the drive the function of the soft charge circuit is bypassed.

Only available on EB, VLT 5000 AQUA and VLT 6000 type units are terminals +DC and –DC. These terminals provide access to the DC bus and are used for load sharing applications. Should these terminals be used as the main supply input to the VLT, provisions would be required for powering the 230VAC cooling fans.

The built in load sharing in the VLT gives the possibility to connect more frequency converters over the DC-bus.

The number of VLT's which can be connected together is in principal infinite, but the VLT's which are connected must be of the same voltage (200-240V or 380-500V).

SECTION TWO

FAULT MESSAGES, WARNINGS, ALARMS

A variety of warning and alarm messages may be displayed. During the warning phase the VLT is operational. The VLT may however be taking action at that time to reduce the condition causing the warning. For example, if the warning displayed were Torque Limit, the VLT would be reducing speed to compensate for the over current condition. If the condition is not corrected before the allotted time expires an alarm condition would be activated. As listed below not all warnings are associated with an alarm and not all alarms are preceded by a warning. With some faults it will not be automatic to move from a warning to an alarm, instead the choice of a warning or alarm trip is determined by programming the specific parameter associated with that fault condition.

In an Alarm State two reset conditions exist. If the display shows TRIP (RESET), the alarm can be manually reset or automatically reset if the Auto Restart Function is enabled.

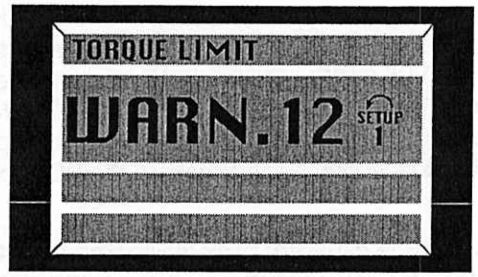
If the display indicates TRIPLOCK (DISC> MAINS) then main input power must be removed long enough for the display to go blank and then reapplied. Following power up the Triplock will change to TRIP (RESET) and allow for a manual reset.

Also note that the Local Stop key and Reset key are one in the same. By pressing the Stop/Rest key the fault is reset and Local Stop is initiated. To run either local or remote the Local Start key must be pressed.

WARNINGS

Warning and alarm messages vary depending on the particular VLT model. The parameters that effect the warnings and alarms also vary and are noted in the fault descriptions.

The display flashes between normal state and warning. A warning comes up on the first and second line of the display. See examples below:



ALARM MESSAGES

The alarm comes up in lines 2 and 3 of the display, see the example below:

WARNING 1
Under 10 Volts (10 VOLT LOW):
The 10VDC supply on terminal 50 of the control card is too low. This condition may be caused by overloading terminal 50 or a short circuit in the Speed Potentiometer or related wiring. Max capacity of terminal 50 is 17 mA. The 10V DC supply on terminal 50 is supplied from a 13 volt regulator that supplies option boards and the LCP. If the 10V DC is missing or low the most common link would be the control card as the faulty part (after the external wiring was removed and verified).

WARNING/ALARM 2
Live zero fault (LIVE ZERO ERROR):
The current signal on terminal 60 is less than 50% of the value programmed in parameter 315, and parameters 317 and 318 have been programmed for the time out function to be active. It is possible to choose between a warning only or a warning and trip based on the selection of parameter 318. Manual reset is possible once the fault is corrected.

WARNING/ALARM 3
No motor (NO MOTOR):
The motor check function has been activated in parameter 122. During stop conditions the motor check is performed. This warning will appear if the VLT fails to detect a motor. (Not applicable for the VLT 5000 AQUA/6000 series.)

WARNING/ALARM 4
Phase fault (AC LINE PHASE LOSS):
One phase of the input AC line is missing or extremely low, or severe waveform distortion is present on the input line. An alarm condition will automatically follow the warning. Trip lock will require power to be cycled before reset. This alarm is derived from reading the AC ripple on the DC Bus. Measuring the input voltage and verifying the wave form may be the first step to restoring proper operation of the drive. Refer to the application section in section II for more Information.

WARNING 5
Voltage warning high (DC LINK VOLTAGE HIGH):
The intermediate circuit voltage (DC) is above the upper warning limit of 825VDC. The VLT is still operational. Refer to the application section in section II for more Information.

WARNING 6
Voltage warning low (DC LINK VOLTAGE LOW):
The intermediate circuit voltage (DC) is below the lower warning limit of 435VDC. The VLT is still operational.

WARNING/ALARM 7
Overvoltage (DC LINK OVERVOLT):
The intermediate circuit voltage (DC) is above the overvoltage limit of 850VDC. The voltage detected will be displayed. It may be necessary to use dynamic braking. As an alternative in the VLT 5000 the Over Voltage Control (OVC) scheme can be activated in parameter 400. For the VLT 5000 AQUA/6000 the OVC function is always active. The setting of parameters 400 and 410 have no effect on this alarm. Manual reset is possible. Warns for 5 sec's trips after 25 sec. Refer to the application section in section II for more Information.

WARNING/ALARM 8
Under voltage (DC LINK UNDERVOLT):
The intermediate circuit voltage (DC) is below the Under voltage limit of 400VDC. The unit will trip after a set period of time. On the VLT 5000 extended units with an external 24VDC supply, this message will be displayed as long as input power is removed, however, the unit will not trip. The voltage level detected will be displayed. Manual reset is possible.

WARNING/ALARM 9
Inverter overload (INVERTER TIME):
The unit has been operating with the output current having been in the intermittent range (between 100% and 150%) for too long. A warning will be displayed when the ETR counter reaches 98%. When the counter reaches 100%, the drive will trip. The unit can be programmed to display the ETR counter. Using a clamp on amp meter verify current going to the motor. Manual reset is only possible after the counter has gone below 90%.

WARNING /ALARM 10
Motor over temperature (MOTOR TIME):
The unit's ETR function has calculated an over temperature condition in the motor. This calculation is based on motor current, speed and the length of time these conditions exist, based on the settings of parameters 102 through 106. Based on the selection in parameter 128 the unit will display a warning or an alarm when the counter reaches 100%. Verify parameters 102 - 106 are set correctly. Also use a clamp on amp meter to check motor amperage. Manual reset is possible after the ETR counter has counted to zero.

WARNING/ALARM 11
Motor thermistor (MOTOR THERMISTOR):
The motor thermistor function has been activated in parameter 128 and a thermistor is connected to either terminal 53 or 54 and programmed as such in parameter 308 or 311. Parameter 128 provides a choice of warning or alarm. This warning or trip indicates the input to terminal 53 or 54 is more than 3K Ohms impedance between that terminal and terminal 50. It is also possible that the connection has been broken. Manual reset is possible.

WARNING/ALARM 12
Torque limit (TORQUE LIMIT/CURRENT LIMIT):
The torque requirement of the motor is higher than the value set in parameter 221 for the VLT 5000 or 215 for the VLT 5000 AQUA/6000(in motor operation) or parameter 222 (regenerative operation). The warning will be present until the time programmed in parameter 409 for VLT 5000 or 412 for the VLT 5000 AQUA/6000 expires. If the current exceeds the VLT continuous rating or motor rating and parameter 128 is set for ETR trip/thermistor, the drive will trip on either alarm 9 or 10. Manual reset is possible.

WARNING/ALARM 13
Over current (OVERCURRENT):
The peak output current limit of the unit has exceeded 165% of the unit's rating. After 1.5 seconds the unit will trip. This fault may be caused by shock loading or fast accel ramps with high inertia loads. Incorrect settings of various group 1 parameters may also be the cause. This fault results in a Trip Locked condition. Refer to the application section in section II for more Information.

ALARM 14
Earth fault (EARTH FAULT):
The unit has sensed output leakage current sufficient enough to determine that there is a ground fault in the motor or motor wiring. This fault results in a Trip Locked condition. Refer to the application section in section II for more Information.

ALARM 15
Switch mode fault (SWITCH MODE FAULT):
The internal plus and/or minus 14VDC power supply voltage is not within the specified range. This fault results in a Trip Locked condition.

ALARM 16
Short-circuiting (CURR.SHORT CIRCUIT):
This indicates the existence of a phase to phase short circuit condition in the motor wiring. This fault results in a Trip Locked condition. Refer to over current section in the application section.

WARNING/ALARM 17
Standard bus time out (STD BUS TIMEOUT):
Indicates the serial communication with the VLT has failed and the time out function has been activated. The delay time programmed determines how long the warning will be present before a trip, provided "stop and trip" has been selected. Manual reset is possible.

WARNING/ALARM 18
HPFB bus timeout (HPFB BUS TIMEOUT):
Indicates the communication between a field bus option (such as DeviceNet) and the VLT has failed and the time out function has been activated in parameter 804. The delay time programmed in parameter 803 determines how long the warning will be present before a trip, provided "stop and trip" has been selected in parameter 804. Manual reset is possible.

WARNING 19
Fault in the EEprom on the power card (EE ERROR POWER CARD):
A fault exists in the ability of the VLT to read and write information to the power card EEPROM. The drive will operate normal and in most cases once power is cycled the warning clears. If the problem halts operation replacement of power card may be needed.

WARNING 20
Fault in the EEprom on the control card (EE ERROR CTRL CARD):
A fault exists in the ability of the VLT to read and write information to the control card EEPROM. The drive will operate normally and in most cases once the power is cycled the warning clears. If the problem halts operation replacement of control card may be needed.

ALARM 21
Auto-optimization OK (AUTO MOTOR ADAPT OK):
The automatic motor tuning function has been completed successfully. It is necessary to manually reset to resume normal operation. (Not applicable for the VLT 5000 AQUA/6000.)

ALARM: 22
Auto-optimization not OK (AUTO MOT ADAPT FAIL):
The automatic motor tuning function failed. The possible causes as shown in the display are listed below. The numbers in brackets will be logged as the value in parameter 617.

CHECK P.103, 105 [0]
Parameter 102, 103 or 105 have incorrect settings. Correct the setting and start AMA all over.

LOW P. 105 [1]
The value entered in parameter 105 is too small for the VLT 5000. Correct the value. Note: the motor nameplate current, and that value entered in parameter 105, must be greater than 35% of the nominal rating of the VLT in order to carry out AMA.

ASYMMETRICAL IMPEDANCE [2]
AMA has detected asymmetrical impedance in the windings of the motor connected. The motor may be defective.

MOTOR TOO BIG [3]
The motor is too large for AMA to be carried out or the setting in parameter 102 is incorrect.

MOTOR TOO SMALL [4]
The motor is too small for AMA to be carried out or the setting in parameter 102 is incorrect.

TIME OUT [5]
AMA has failed after attempting to tune for a period in excess of what should be normal. It is possible that the signal data being returned is noisy. It is possible to make several attempts under these conditions and eventually get the unit to pass.

INTERRUPTED BY USER [6]
The AMA function has been interrupted by the user.

INTERNAL FAULT [7]
A fault has occurred internal to the VLT. Contact the factory.

LIMIT VALUE FAULT [8]
The parameter values programmed for the motor are outside the typical characteristics of the VLT's internal motor table. AMA cannot be performed on this particular motor.

MOTOR ROTATES [9]
The motor shaft rotated during the tuning process. Ensure the load is not capable of rotating the shaft. AMA may be started over.

WARNING/ALARM 23
Fault during brake test (BRAKE TEST FAILED):
When a unit with braking is powered-up and a stop command is present, a brake test is performed automatically by the unit. If the result of this test indicates a fault condition in the brake circuit and parameter 404 is set to warning, a warning will be displayed. If *Trip* has been set in 404 an alarm will occur. Possible causes for this are: No brake resistor connected, faulty connection to the brake resistor, defective brake resistor or a defective brake IGBT. The unit will be able to operate in this condition, however, the brake function will be inoperative. Manual reset is possible. (Not applicable for the VLT 5000 AQUA/6000.)

WARNING 25
Brake resistor fault (BRAKE RESISTOR FAULT):
The brake resistor or the connection is short circuited. The unit will be able to operate in this condition, however, the brake function will be inoperative. Manual reset is possible. (Not applicable for the VLT 5000 AQUA/6000.)

WARNING 26
Brake resistor power 100% (BRK PWR WRN 100%):
The monitoring function has been activated in parameter 403. The power transmitted to the brake resistor is monitored over a 120 second period. The power is based on the values entered in parameters 401 and 402. If the calculated power being dissipated exceeds 100% a warning will occur based on the choice in parameter 403. If warning is selected the warning will disappear when the dissipated power drops below 80%. Manual reset is possible. (Not applicable for the VLT 5000 AQUA/6000.)

WARNING 27
Brake transistor fault (BRAKE IGBT FAULT):
The brake transistor is shorted. As a result of the shorted transistor substantial power may be transmitted to the brake resistor. Disconnect main input power to the VLT. It may be possible to run with the brake resistor disconnected but the braking function will be inoperative. (Not applicable for the VLT 5000 AQUA/6000.)

ALARM 29
Heat sink temperature too high
(HEAT SINK OVER TEMP.):
The heatsink temperature has exceeded 95°C. The possible causes are: defective cooling fan, blocked heat sink or air flow path, defective thermal sensor or possibly incorrect mounting to a flush surface to ensure proper airflow across the heatsink. This fault results in a Trip Locked condition. Additionally there are four LED's on the Power Card that are associated with an Over Temperature alarm. Reference application section.

LED 1:
This LED will be lit when the power card temperature sensor has determined the VLT's internal ambient temperature to be above 85°C. The sensor will automatically reset when the temperature drops below 70°C.

LED 2:
This LED will be lit when the power card temperature sensor has determined the VLT's internal ambient temperature to be below minus 20°C. The sensor will automatically reset when the temperature rises above minus 5°C.

LED 3:
This LED will be lit when the thermal switch on the output inductor or mounted on the left side of capacitor bank, depending on age of drive, detects a temperature in excess of 135°C. The sensor will automatically reset. As this sensor is a switch, the temperature displayed will typically be the default value of 139°C. This is not the actual temperature that has been sensed.

LED 4:
This LED will be lit when the connection at MK15 (external disable) has been activated. Based on the way MK15 is wired this could mean the external input has closed or become open. As this input is closed or open, the temperature displayed will typically be the default value of 139°C. This is not the actual temperature that has been sensed.

ALARM 30
Motor phase U missing (MISSING MOT. PHASE U):
The unit has detected an open circuit in the U phase. This fault may be manually reset. Parameter 234 (VLT 5000 only) can disable the triping or missing motor phase.

ALARM 31
Motor phase V missing (MISSING MOT. PHASE V):
The unit has detected an open circuit in the V phase. This fault may be manually reset. Parameter 234 (VLT 5000 only) can disable the triping or missing motor phase.

ALARM 32
Motor phase W missing (MISSING MOT. PHASE W):
The unit has detected an open circuit in the W phase. This fault may be manually reset. Parameter 234 (VLT 5000 only) can disable the triping or missing motor phase.

ALARM 33
Quick discharge not failure
(QUICK DISCHARGE NOT OK):
This indicates that the Quick Discharge feature is not functioning. Possible causes are: No 24V external power supply, brake resistors not connected properly. Sequence of operation not correct. This fault results in a Trip locked condition. This feature is available only with the VLT 5000 EB version.

WARNING/ALARM 34
Profibus communication fault
(PROFIBUS COMMUNICATION FAULT):
The Profibus option is no longer communicating. In a warning state this may indicate the cable has been disconnected or the master has stopped. In an alarm state it may indicate the option card is disturbed by noise or possibly defective. A trip can be manually reset.

WARNING 35
Out of frequency range (OUT OF FREQ. RANGE):
This warning will only be displayed when operating in Process Closed Loop and the output frequency of the VLT is above or below the limits programmed in parameters 201 and 202. Parameter 455 (VLT 5000 only) can be disabled to eliminate this warning.

WARNING/ALARM 36
Mains failure (MAINS FAILURE):
The mains failure function has been activated in parameter 407. A choice of actions are available including whether or not to trip . A trip can be manually reset. (Not applicable for the VLT 5000 AQUA/6000.)

ALARM 37
Inverter fault (INVERTER FAULT):
Indicates an IGBT or the power card is defective. This fault results in a Trip Locked condition. Verify signals coming from the power card, also verify the gate to emitter resistance on the IGBT for problems.

WARNING 39
CHECK Parameter 104, 106:
The settings in parameter 102, 104 or 106 are possibly incorrect. Check the setting and choose "Continue" or "Stop:. If stop is selected AMA will have to be started over.

WARNING: 40
CHECK Parameter 103, 105:
The settings in parameter 102, 103 or 105 are possibly wrong. Check the setting and choose "Continue" or "Stop". If stop is selected AMA will have to be started over.

WARNING 41
MOTOR TOO BIG:
The motor is too large for the VLT or the setting of parameter 102 is incorrect. Check the motor and setting and choose "Continue" or "Stop". If stop is selected AMA will have to be started over.

WARNING 42
MOTOR TOO SMALL:
The motor is too small for the VLT or the setting of parameter 102 is incorrect. Check the motor and setting and choose "Continue" or "Stop". If stop is selected AMA will have to be started over.

ALARM 43
Brake fault (BRAKE FAULT):
A test of the brake function has failed. The possible causes as shown in the display are listed below. The numbers in brackets will be logged as the value in parameter 617. These failures result in a Trip Locked condition. (Not applicable for the VLT 5000 AQUA/6000.)

Brake check failed
(BRAKE CHECK FAILED) [0]
During power up the brake test failed to find a resistor connected. Verify proper connections have been made to the VLT 5000.

Brake resistor short-circuited
(BRAKE RESISTOR FAULT) [1]
During the brake test the VLT 5000 has found a short circuit at the brake terminals. Verify no shorts exist at the terminals and the brake resistor is the proper value for the VLT 5000.

Brake Transistor short-circuited
(BRAKE IGBT FAULT) [2]
The brake transistor is shorted. As a result of the shorted transistor substantial power may be transmitted to the brake resistor. Disconnect main input power to the VLT 5000. It may be possible to run with the brake resistor disconnected but the braking function will be inoperative.

WARNING/ALARM 44
ENCODER LOSS (ENCODER FAULT)
The encoder signal is interrupted from terminal 32 or 33. Check the connections of encoder device.

The following warning/Alarms are only applicable to the VLT 5000 AQUA/6000.

WARNING: 62
Output frequency high (FOUT>FHIGH)
The output frequency is higher than parameter 224
Warning: High frequency, f_{HIGH}

WARNING?ALARM: 63
Output current low(I MOTOR<I HIGH)
The output current is lower than parameter 221 *Warning: Low current,* I_{LOW}. Select the required function in parameter 409 function in case of no load.

WARNING: 64
Output current high (I MOTOR>I HIGH)
The output current is higher than parameter 222 *Warning: High current,* I_{High}.

WARNING: 65
Feedback low (FEEDBACK<FDB LOW)
The resulting feedback value is lower than parameter 227
Warning: Low feedback, FB_{LOW}

WARNING: 66
Feedback high (FEEDBACK>FDB HIGH)
The resulting feedback value is higher than parameter 228
Warning: High feedback, FB_{HIGH}

WARNING: 67
Remote reference low (REF.<REF LOW)
The remote reference is lower than parameter 225
Warning: Low reference, REF_{LOW}

WARNING: 68
Remote reference high (REF.>REF HIGH)
The remote reference is higher than parameter 226
Warning: High reference, REF_{HIGH}

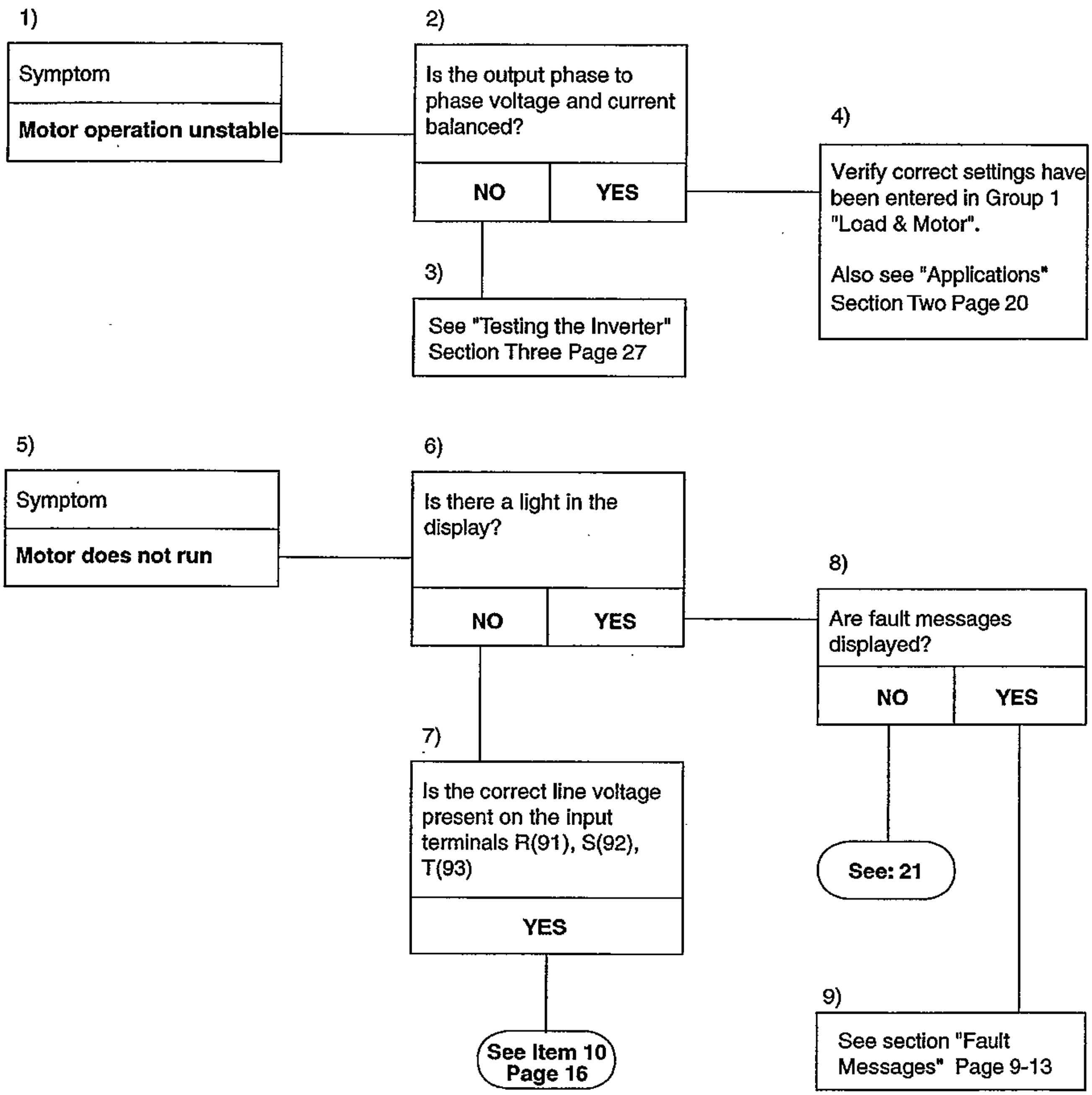
WARNING: 69
Temperature auto derate (TEMP.AUTO DERATE)
The heatsink temperature has exceeded the max value and the auto derating function (par. 411) is active.
Warning: Temp. auto derate.

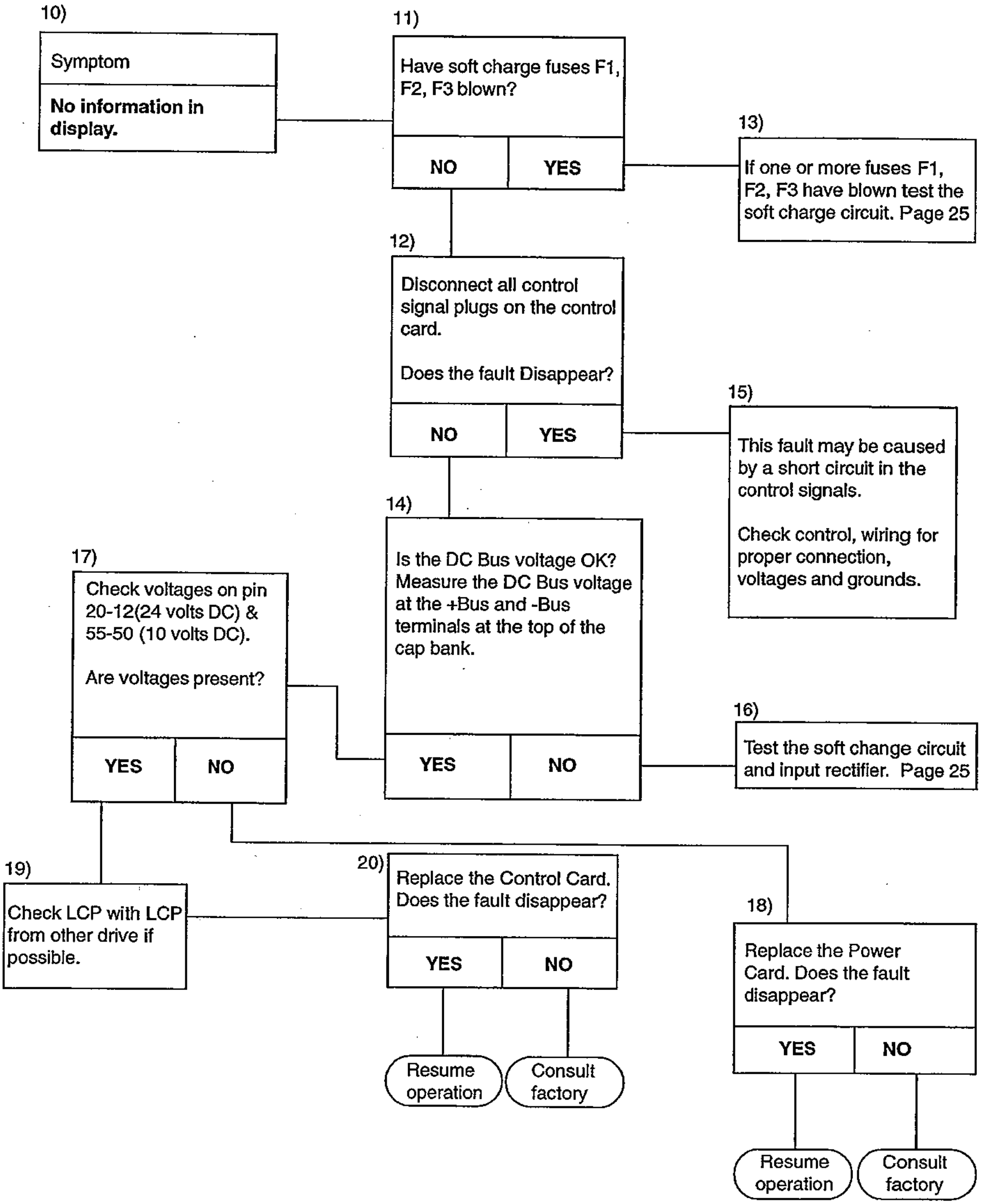
WARNING: 99
Unknown fault (UNKNOWN ALARM)
An unknown fault has occurred which the software is not able to handle. Cycle power and or reinitialize the VLT to clear the fault. Possible replacement of control card is needed.

GENERAL TROUBLESHOOTING TIPS

Prior to diving into a repair here a few tips if followed will make the job easier and may prevent unnecessary damage to good components.

1. First and foremost respect the voltages produced by the drive. Always verify the presence of line voltage and bus voltage before working on the unit. Also remember that some points in the drive are referenced to the negative bus and are at bus potential even though you may not expect it.
2. Never power up a unit which has had power removed and is suspected of being faulty. If a short circuit exists within the unit applying power is likely to result in further damage. The safe approach is to conduct the Static Test Procedures starting in section three. The static tests check all high voltage components for short circuits. The tests are relatively simple to make and can save money and downtime in the long run.
3. The safest method of conducting tests on the drive is with the motor disconnected. In this way a faulty component that was overlooked or the unfortunate slip of a test probe will generally result in a unit trip instead of a component failure.
4. Following the replacement of parts test run the unit with the motor disconnected. Start the unit at zero speed and slowly ramp the speed up until the speed is at least above 40 Hz. Monitor the phase to phase output voltage on all three motor terminals to check for balance. If balanced the unit is ready to be tested on a motor. If not, further investigation is necessary.
5. Never attempt to defeat fault protection devices within the drive. This will only result in unwanted component damage and may result in personal injury as well.
6. Always use factory approved replacement parts. The unit has been designed to operate within certain specifications. Incorrect parts may effect the tolerance and result in further damage to the unit.
7. Read the instruction and service manuals. A thorough understanding of the unit is the best approach. If ever in doubt consult the factory or an authorized repair center for assistance.


1)
Symptom
Motor operation unstable
2)
Is the output phase to phase voltage and current balanced?
NO
YES
3)
See "Testing the Inverter" Section Three Page 27
4)
Verify correct settings have been entered in Group 1 "Load & Motor".
Also see "Applications" Section Two Page 20
5)
Symptom
Motor does not run
6)
Is there a light in the display?
NO
YES
7)
Is the correct line voltage present on the input terminals R(91), S(92), T(93)
YES
See Item 10 Page 16
8)
Are fault messages displayed?
NO
YES
See: 21
9)
See section "Fault Messages" Page 9-13


10)
Symptom
No information in display.
11)
Have soft charge fuses F1, F2, F3 blown?
NO
YES
13)
If one or more fuses F1, F2, F3 have blown test the soft charge circuit. Page 25
12)
Disconnect all control signal plugs on the control card.
Does the fault Disappear?
NO
YES
15)
This fault may be caused by a short circuit in the control signals.
Check control, wiring for proper connection, voltages and grounds.
14)
Is the DC Bus voltage OK? Measure the DC Bus voltage at the +Bus and -Bus terminals at the top of the cap bank.
YES
NO
16)
Test the soft change circuit and input rectifier. Page 25
17)
Check voltages on pin 20-12(24 volts DC) & 55-50 (10 volts DC).
Are voltages present?
YES
NO
19)
Check LCP with LCP from other drive if possible.
20)
Replace the Control Card. Does the fault disappear?
YES
NO
Resume operation
Consult factory
18)
Replace the Power Card. Does the fault disappear?
YES
NO
Resume operation
Consult factory

21)

Symptom

Motor stationary, info in display but no fault message displayed.

22)

Start the VLT adjustable frequency drive by pressing "Start" on the keyboard.

23)

Is the display frozen, i.e., the display cannot be changed or is undefinable?

NO → 24) | **YES** → 25)

25)

Replace the Control Card. If this does not help, the fault might be electrical noise. Check whether the following precautions have been taken:

- Have shielded cables been used?
- Are the shields correctly terminated?
- Is the unit properly grounded to earth?

24)

Is the motor connected correctly?

YES → 27) | **NO** → 26)

26)

Correct motor wiring

Insure motor overloads are reset, output conductor closed and wire terminal connections are not loose

CAUTION:

Prior to running In Local, insure all other equipment associated with the VLT is ready to function or has been Isolated.

27)

Attempt to run the VLT in local. <u>See caution at left.</u>
Make the following parameter settings:
parameter 002 = Local
parameter 013 = LCP Ctrl/ open loop
parameter 003 = Freq. ref.

Does the motor run?

YES → 29) | **NO** → 28)

28)

Replace the Control card.

Does the motor run?

NO → Consult factory | **YES** → Resume operation

29)

Verify that the control signals are connected to the correct terminals and the appropriate parameter settings have been entered.

30)

Replace the Power Card.

Does the motor run?

NO → Consult factory | **YES** → Resume operation

SYMPTOM/CAUSE CHARTS

SYMPTOM/CAUSE charts are generally directed towards the more experienced technician. The intent of these charts is to provide a range of possible causes for a specific symptom. In doing so, these charts provide a direction, but with limited instruction.

SYMPTOM	POSSIBLE CAUSES
1. Control Card Display Is Not Lit.	Incorrect or missing input voltage Incorrect or missing DC bus voltage Remote control wiring loading the power supply Defective Control/Power Card Defective LCP Defective or disconnected ribbon cables
2. Blown Input Line Fuses	Shorted SCR/Diode module Shorted IGBT
3. Blown Soft Charge Fuses	Shorted soft charge rectifier Shorted DC bus Shorted brake IGBT Open/ shorted softcharge resistor Shorted fan transformer
4. Motor Operation Unstable (Speed Fluctuating)	Incorrect settings of motor parameters Load compensations set incorrectly Slip Compensation set too high Improper current feedback PID Regulator or Auxiliary Reference mis-adjusted Possible single phase motor
5. Motor Draws High Current But Cannot Start. (May appear to rock back and forth.)	Open winding in motor Open connection to motor One inverter phase missing. Test output phase balance. Ramp up time to short
6. Motor Runs Unloaded But Stalls When Loaded. (Motor may run rough and VLT may trip.)	One half of one inverter phase missing. Test output phase balance. Over magnetizing motor check motor parameters.

SYMPTOM/CAUSE CHARTS

SYMPTOM/CAUSE charts are generally directed towards the more experienced technician. The intent of these charts is to provide a range of possible causes for a specific symptom. In doing so, these charts provide a direction, but with limited instruction.

SYMPTOM	POSSIBLE CAUSES
7. Unbalanced Input Phase Currents *Note: Slight variations in phase currents is normal. Variations greater than 5% require investigation.*	Input line voltage unbalanced Faulty connection on input wiring Fault in plant power transformer Input SCR/Diode module faulty or not being gated.
8. Unbalanced Motor Phase Currents *Note: Slight variations in phase currents is normal. Variations greater than 5% require investigation.*	Open motor winding Faulty motor connection Fault in inverter section (see Symptom No. 6.) Motor parameters

APPLICATIONS

TORQUE LIMIT, CURRENT LIMIT, OR UNSTABLE MOTOR OPERATION

Excessive loading of the VLT may result in the unit displaying Torque Limit, Over current or possibly tripping on Torque Limit, Over current, or Inverter Time. This is not a concern if the VLT has been properly sized for the application and intermittent load conditions cause anticipated operation in Torque Limit or an occasional trip. Nuisance unexplained occurrences may be the result of improperly setting specific parameters. The following parameters are critical to the VLT/ Motor relationship:

Parameters 100 through 109 and the setting of parameters 221 and 409.

Parameters 100 and 101 configure the VLT for a specific mode of operation.

Parameter 100 sets the VLT for open or closed loop operation or torque mode operation. In a closed loop configuration it is necessary that a feedback signal is received by the unit. In turn the settings for the PID controller play a key role in the stable operation of the VLT.

Parameter 101 sets the VLT for constant or variable torque operation. Based on the application it is imperative that the correct torque characteristic is selected. If for example the load type was such that it was constant torque, such as a conveyor, and variable torque was selected, the VLT may have great difficulty starting the load if not at all. Consult the factory if you are unsure of the torque characteristics of your application.

Parameters 102 through 106 configure the VLT for the motor connected. With the VLT Series the accuracy of these parameters are of great importance. For the VLT to be effective and efficient in controlling the load the unit relies on this information for making calculations that result in corrections to the output waveform based on the changing demands of the application.

Parameter 107 activates the Automatic Motor Adaptation function. As the VLT queries the motor it sets various parameters based on the findings. Two key parameter values which are set by this function are Stator Resistance and Stator Reactance, Parameters 108 and 109. If you are experiencing unstable motor operation and have not performed AMA, it should be done. Remember however, that AMA can only be performed on a single motor application, and then only within the programming range of the VLT. Consult the instruction manual for more on this function.

Parameters 108 and 109 as stated earlier are set by the AMA function or should be left at their factory default value. Never adjust these parameters to any random values even though it may seem to improve the operation. Such adjustments may appear to improve operation under a single set of circumstances but should the conditions change the result may be unpredictable.

Parameter 221 sets the level at which the VLT limits torque. The factory setting is 160% and 110% for 5000 Aqua/6000 and will vary up and down with the setting of motor power. For example, a VLT 5150 programmed to operate a smaller motor will yield a higher torque limit value than the same unit programmed to operate an equivalent or larger size motor. It is important that this value not be set too low for the requirements of the application. In some cases it is desirable to have a torque limit set at a lesser value, lets say for example 120%. This offers protection for the application in that the VLT will limit the torque to that value. It may however be the case that during initial start up the load requires 130% torque. Under these circumstances nuisance tripping may be the result.

Parameter 409 works in conjunction with parameter 221. This parameter allows you to select a time that the VLT will operate in torque limit and then trip. The factory default value is set to off. A setting of Off does indeed mean that the VLT will not trip on torque limit but doesn't mean it will never trip from an overload condition. Built into the VLT is the internal Inverter Thermal Protection circuit. This circuit monitors the output load on the inverter. If the load exceeds 100% of the VLT continuous rating the counter begins counting. If the load remains there long enough the counter will count to 100% and the VLT will trip on Inverter Time. No adjustments can be made to alter this circuit however, the settings of the parameters listed above can effect load current and result in premature trips of this type. You can view the counter in the display.

EARTH FAULT TRIPS

Trips occurring from ground faults are usually the result of short circuits to earth ground either in the motor or the wiring to the motor. The VLT detects ground faults by monitoring all three phases of output current and looking for severe imbalances in those currents. When a "Ground Fault" trip occurs it is necessary to measure the resistance of the motor windings and wiring with respect to earth ground. The instrument normally used for this purpose is a Megohmmeter or commonly referred to as a "Megger". Many times these resistance readings are taken with a common Ohmmeter, which is actually incapable of detecting any shorts other than those that are virtually direct. A Megger has the capability of supplying higher voltages, typically 500 volts or more, which enables the Megger to detect breakdowns in insulation or higher resistance shorts which cannot be picked up through the use of an Ohmmeter. When making resistance measurements to ground, it is necessary to disconnect the motor leads from the output of the VLT. The measurements should then be taken at the point of connection to the VLT so the motor and all associated wiring and connections are captured in the test. When reading the results of the Megger test, the rule of thumb is any reading less than 500 Megohms should be suspect. Solid, dry wiring connections normally result in a reading of infinity.

As stated the VLT detects ground fault conditions by monitoring the current through the hall effect current sensors on the output of the unit. The three signals from these sensors is sent to power card and then summed together. When no earth current is flowing the sum of these three currents will be zero. A defective current sensor could then be the cause of an Earth Fault. If for example the signal from one sensor is missing the sum of the three currents would not equal zero and an earth fault would occur. This is normally only seen when the load current is significant since the current imbalance must be in excess of the maximum continuous rating of the VLT. It could further be the case that the signal from the current sensor is present but offset from zero. The signals midpoint must be zero with the maximum peaks reaching the level of the + and – 14 volt sensor power supply. This offset and or the lack of a signal can be observed on the signal board. See the section on testing current feedback.

It is also possible that if an earth fault occurs when the motor is under power the result may actually be an Overvoltage Trip. This is due to the fact that when the earth fault occurs the DC bus can increase rapidly to as much as 200 volts over its nominal value. Also see the explanation on Overvoltage Trips later in this section.

OVER CURRENT TRIPS

The VLT detects over current conditions by monitoring the current output of all three phases. An over current condition exists when the current in an individual phase exceeds 165% of the units maximum overload rating. At that point the IGBT's in that phase are turned off. Shortly after turning off, the IGBT's will once again be gated on as the current in that phase will have dropped. This turning on and off of the IGBT's will continue for up to 1.5 seconds after which time the VLT will trip on Over current.

Over current trips may occur as a result of attempting to start a jammed load, energizing an output conductor while the VLT is already running at a given speed, attempting to start a high inertia load with short acceleration ramps, attempting to start windmilling load, or a phase to phase short on the output of the VLT. It may also be the case that the over current trip is a phantom occurrence caused by incorrect settings of motor parameters as was discussed earlier. Except for the latter all of these conditions are relatively simple to diagnose.

The VLT incorporates some features that can be used to overcome some of the conditions mentioned. One such feature is Flying Start. This feature is helpful in starting windmilling loads. An example of such a load is a fan that while it is not powered it is being driven by airflow through the duct work. As the VLT is started it begins ramping from zero frequency. Since the load is not at zero the VLT must first brake the load to zero and then begin ramping from there. This consumes large amounts of current, almost as what could be seen in applying a plug reverse to a motor to bring it to a stop. By enabling the Flying Start function, when a run command is given, the VLT searches the frequency range looking for the actual speed of the motor. Once found the VLT starts its ramp from that frequency and then carries the load up or down to the commanded speed.

Solving over current trips due to fast acceleration ramps or closing a conductor on the output can be solved easily by adapting the ramp time and sequence of operation to within the limits of the VLT. This is not always possible as the methods used to control the application are required to function in such a way. It may be the case that given the circumstances the VLT is undersized for the application requirements. It may also be possible to adjust the VLT to perform under these circumstances. Running the AMA function should be the first step in optimizing the VLT to the motor. Following that, an adjustment of the load compensations may give favorable results. If all else fails consult the Application Engineering group at Danfoss for further assistance.

OVERVOLTAGE TRIPS

This trip occurs when the DC bus voltage reaches a level of approximately 840VDC. Prior to the trip the VLT will display warnings of high voltage. Most times an over voltage condition is due to fast deceleration ramps with respect to the inertia of the load. As an attempt is made to decelerate the load the inertia of the system will act to sustain the running speed. Once the frequency of the motor drops below the running speed the load begins overhauling the motor. At this point the motor becomes a generator and starts returning energy to the VLT. This is called regenerative energy. This return voltage is rectified by the diodes in the IGBT modules and raises the DC bus. If the amount of returned voltage is more than the unit can consume the VLT will trip.

There are a few ways to overcome this situation. One method is to increase the deceleration rate so it takes longer for the VLT to decelerate to a new speed or come to a stop. A general rule of thumb is that the drive can only decelerate the load slightly faster than it would take for the load to naturally coast to a stop. A second method is to allow the Overvoltage control circuit to take care of the deceleration ramp. When enabled in parameter 400 the over voltage control circuit will regulate the deceleration ramp at a rate that maintains the DC bus at an acceptable level. One caution with over voltage control, it is set up in such a way that it will not make corrections to unrealistic ramp rates. For example if the deceleration ramp needs to be 100 seconds due to the inertia, and you set the ramp rate for 3 seconds, over voltage control will initially engage and then disengage and allow the VLT 5000 to trip. This is purposely done so the units operation is not misinterpreted. The third method in controlling regenerated energy is with a dynamic brake. With this system the optional brake electronics are built into the VLT and an external resistor bank is mounted outside of the VLT. The drive monitors the level of the DC bus. Should the level become too high the electronics will switch the resistor across the DC bus and dissipate the unwanted energy into the resistor bank. This is the only means available to actually increase the rate of deceleration.

Less often is the case that the over voltage condition is caused by the load while it is running at speed. In this case the dynamic brake option can be used but you may also choose to activate the over voltage control circuit. It works with the load in this way. As stated earlier regeneration occurs when the speed of the load is greater than the commanded speed. If the load should become regenerative while the unit is running at a steady state speed, the over voltage circuit will increase the frequency to match the speed of the load.

Remember for the load to become regenerative it must be running faster than the commanded speed. The same restriction on the amount of influence applies. The VLT will only add 10% to the base speed before a trip occurs. Otherwise, in theory, the speed could continue to rise to levels that may be unsafe.

MAINS PHASE LOSS TRIPS

The VLT actually monitors phase loss by monitoring the amount of ripple voltage on the DC bus. The VLT uses this method because although ripple voltage on the DC bus is a product of a phase loss, the main concern is ripple voltage causes overheating in the DC bus capacitors and the DC coil. Left unchecked the lifetime of the capacitors and the DC coil would be drastically reduced.

As the voltage becomes unbalanced or a phase should disappear completely the ripple voltage will increase and the VLT will trip. Other than the obvious missing phase voltage increased bus ripple can be the result of line disturbances or line imbalances. Imbalances or oscilations on the output voltages or current will also simulate the Alarm 4 symptoms. Line disturbances may be caused by line notching, defective transformers or other loads that may be effecting the form factor of the AC waveform. Line imbalances which exceed 3% will cause sufficient DC bus ripple to initiate a Mains Phase Loss Trip.

Severe phase imbalances, or phase losses can easily be detected with a volt meter. Line disturbances will most likely have to be viewed on an oscilloscope.

OVER TEMPERATURE TRIPS

The VLT 5060-5250 monitors the temperature of the heatsink, the internal ambient, and provides for monitoring the temperature of an external device. In addition, VLT 5125-5250 NEMA 12/IP54 type units have a sensor monitoring the surface temperature of the motor coil. In newer units the AC indicator thermal sensor was moved to the left side of the capacitor back. This was done because of a charge to the inductor. The purpose of this sensor was to protect drives internal ambient temperature if door fan filters are clogged or dirty.

For each of the above trip will result in an alarm condition with the display indicating HEAT SINK OVER TEMP. It is then necessary to view the 4 LED's mounted on the power card to further identify the source of the fault. If the display indicates over temp and none of the power card LED's are lit than the source of the fault is the heatsink thermal sensor. This sensor is a Negative Temperature Coefficient (NTC) device. The sensor delivers a resistance value based on temperature and operates within a range of 787 ohms to 105 Kohms, with 787 ohms equal to 95°C. As the temperature rises the resistance decreases and as the temperature falls the resistance increases. A trip caused by the heatsink thermal sensor can be due to the ambient temperature around the unit is too high, the path of the air flow for the heatsink fan is obstructed, the heatsink fan is not operating, or the thermal sensor is defective. Since the fans and the sensor have a relatively long life expectancy, most failures are due to restricted air flow or incorrect installation practices causing poor air circulation. It is important for all chassis drives to be mounted flush on a flat surface to provide a proper air channel. If this is not done the drives fan can only supply air to the upper portion of the heatsink, instead of drawing it across the whole heatsink. Consult the instruction manual for proper installation instructions to ensure spacing and air flow space is provided.

Following is a description of the 4 LED's associated with an over temperature fault.

LED 1:

This led will be lit when the power card temperature sensor has determined the VLT internal ambient temperature to be above 85°C. The sensor will automatically reset when the temperature drops below 70°C.

LED 2:

This LED will be lit when the power card temperature sensor has determined the VLT's internal ambient temperature to be below minus 20°C. The sensor will automatically reset when the temperature rises above minus 5°C.

LED 3:

This LED will be lit when the thermal switch on the output inductor detects a temperature in excess of 135°C. The sensor will automatically reset. As this sensor is a switch, the temperature displayed will typically be the default value of 139°C. This is not the actual temperature that has been sensed.

LED 4:

This LED will be lit when the connection at MK15 (external disable) has been activated. Based on the way MK15 is wired this could mean the external input has closed or become open. As this input is closed or open, the temperature displayed will typically be the default value of 139°C. This is not the actual temperature that has been sensed.

SECTION THREE

NOTE: Remember from discussion in the description of operation section the variations between variable and constant torque units was described. The same will hold true throughout the remainder of this manual. All references will be made to the constant torque versions, VLT 5060-5250. The actual frame of the VLT 5000 AQUA or 6000 series drive will be one size smaller in comparison. For example, if servicing a VLT 5075 AQUA or 6075 refer to the VLT 5060 sections.

STATIC TEST PROCEDURES

The purpose of performing static tests is to rule out the possibility of any shorted power components. These tests should be performed on any unit that is suspected faulty, prior to applying power. Should any component be found defective or suspect, it must be replaced before power can be reapplied to the VLT.

The following static tests are covered in this section:

- Soft Charge and Rectifier Circuit
- Inverter Section
- Intermediate Section or DC Bus
- Miscellaneous

All tests will be made with a meter capable of testing diodes. Use a digital VOM set on the Diode scale or an analog ohmmeter set on R x 100 scale. Before making any checks disconnect all input, motor and brake resistor connections.

CAUTION:
Following the removal of input power, it can take up to 15 minutes for the DC bus capacitors to discharge. Allow sufficient time for the DC bus capacitors to fully discharge before beginning any testing. The presence of DC bus voltage can be tested by connecting a voltmeter set to read up to 1000VDC to the +DC Bus and –DC Bus terminals, Photo 1, located at the top of the capacitor bank.

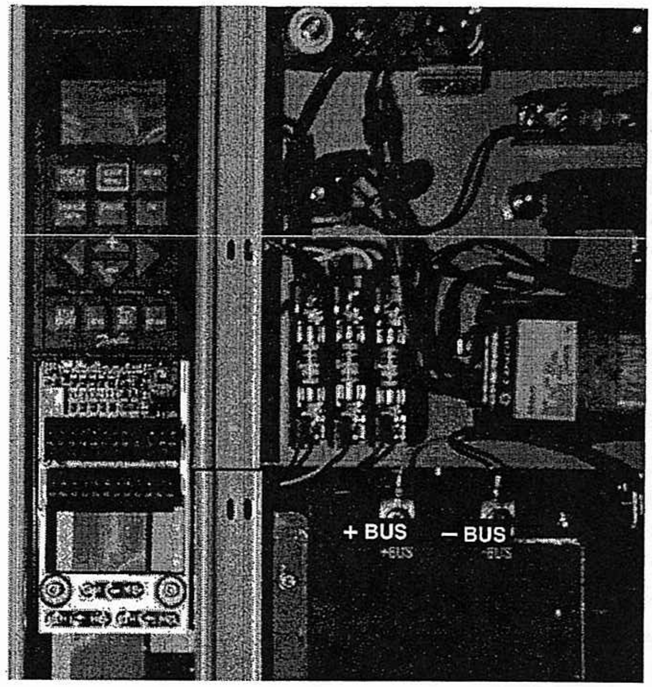


Photo 1

NOTE:

Photo is typical of a VLT 5060-5100 Chassis, others will be similar however, polarity of + and - bus connection is opposite on VLT 5125-5250.

TESTING THE SOFT CHARGE AND RECTIFIER CIRCUIT:

Refer to Photos 2 through 6 starting on page 30 for location of components and test points.

In the "Sequence of Operation" section the function of the soft charge and rectifier circuits were discussed. The soft charge circuit is made up of the soft charge rectifier, resistor fuses and the soft charge resistor. The rectifier circuit is made up of the SCR/Diode modules and included are the lower diodes of the soft charge rectifier which serve as snubber diodes for the SCR portion of the module.

As the tests are carried out both the rectifier and soft charge circuits will be tested simultaneously. It is important to pay close attention to the polarity of the meter leads to ensure you can identify a faulty component should an incorrect reading appear.

Step 1
Prior to making the test it is necessary to ensure the soft charge rectifier fuses, F1, F2, F3 and resistor fuses F4, and F5 if applicable, are good. If not, replace them before proceeding.

Step 2
Connect the positive (+) meter lead to the positive DC bus connection. Connect the negative (–) meter lead to terminals L1, L2, and L3 in turn. Each reading should show infinity. In actuality the meter will start at a low value and slowly climb towards infinity due to capacitance within the drive being charged by the meter.

Incorrect Reading:
With the "Step 2" test connection the SCR's in the SCR/Diode modules are reverse biased so they are blocking current flow. The upper diodes in the soft charge rectifier are also reverse biased so they too are blocking current flow. The upper diodes in the rectifier are blocked from this measurement by capacitor C1. However, if a diode drop was read, this would indicate that one or both of the soft charge resistor thermal sensors were closed. If a short circuit exists it would be possible that either the SCR's or the diodes in the soft charge rectifier are shorted. In this case it would be necessary to remove the soft charge fuses in order to isolate the two devices. Once the fuses are removed make the same measurement to confirm the SCR's. To check the soft charge rectifier make the negative (–) lead connection at the side of the soft charge rectifier fuse block that has the wires which connect to the rectifier.

Step 3
Reverse the meter leads. Connect the negative (–) meter lead to the positive DC bus connection. Connect the positive (+) meter lead to L1, L2, and L3 in turn. Each reading should show a diode drop. Note in some new drives BR2 causes a double diode drop reading .900. Due to the SCR/Snubber Diode assembly (BR2). Reference Section I soft charge circuit.

Incorrect Reading:
With the "Step 3" test connection, even though the SCR's in the SCR/Diode modules are forward biased by the meter, current will not flow through the SCR's without providing a signal to their gates, so they are still blocking current flow. The upper diodes in the soft charge rectifier are forward biased so the meter reads the voltage drop across those diodes. If an open reading were present it would indicate the upper diodes in the soft charge rectifier are open. It could also indicate that one or more of the soft charge rectifier or resistor fuses are open. It could further be the case that the soft charge resistor(s) are open. To check the soft charge resistors place an ohmmeter across the +DC Bus terminal and the resistor fuses. If the unit has a single resistor installed it will read 18 ohms. Two resistors in parallel will read 9 ohms.

A short circuit reading indicates either the upper soft charge rectifier diodes are shorted or the SCR's are shorted in the SCR/Diode module. In this case it would be necessary to remove the soft charge fuses in order to isolate the two devices. Once the fuses are removed make the same measurement to confirm the SCR's. To check the soft charge rectifier make the positive (+) lead connection at the side of the soft charge rectifier fuse block that has the wires which connect to the rectifier.

Step 4
Connect the positive (+) meter lead to the negative DC bus connection. Connect the negative (–) meter lead to terminals L1, L2 and L3 in turn. Each reading should show a diode drop.

Incorrect Reading:
With the "Step 4" test connection the diodes in the SCR/Diode modules are forward biased as well as the lower diodes in the soft charge rectifier so the meter reads the diode drops. If a short circuit exists it would be possible that either the diodes in the SCR/Diode modules or the lower diodes in the soft charge rectifier are shorted. In this case it would be necessary to remove the soft charge fuses in order to isolate the two devices. Once the fuses are removed make the same measurement to confirm the diodes in the SCR/Diode modules. To check the soft charge rectifier make the negative (–) lead connection at the side of the Soft Charge Rectifier fuse block that has the wires which connect to the rectifier.

Step 5
Reverse the meter leads. Connect the negative (–) meter lead to the negative DC bus connection. Connect the positive (+) meter lead to L1, L2 and L3 in turn. Each reading should show infinity. Remember the same is true as before. The meter will move slowly towards infinity as it charges the capacitance within the drive.

Incorrect Reading:
With the "Step 5" test connection, the diodes in the SCR/Diode modules are reversed biased as well as the lower diodes in the soft charge rectifier. If a short circuit exists it would be possible that either the diodes in the SCR/Diode modules or the lower diodes in the soft charge rectifier are shorted. In this case it would be necessary to remove the soft charge fuses in order to isolate the two devices. Once the fuses are removed make the same measurement to confirm the diodes in the SCR/Diode modules. To check the soft charge rectifier make the positive (+) lead connection at the side of the soft charge rectifier fuse block that has the wires which connect to the rectifier.

Step 6
To complete the testing of the soft charge circuit, measure the soft charge resistors to ensure they are the correct value. Make this reading by placing the meter across the negative connection of BR2 and the resistor fuses. Remember to reset your meter to read ohms on its lowest scale. One soft charge resistor will read 18 ohms. If two resistors are used, they are connected in parallel so they will read 9 ohms. If a short were to be present it could indicate the resistors are shorted or the thermostats mounted to the resistors have closed. An open reading of course indicates the resistor is open. An 18 ohm reading on two parallel resistors would indicate one of the resistors is open. In any case the faulty components must be replaced.

Indications of a failure in this circuit:
In rare instances a failure of a component in this circuitry may be just that, a component failure. That is however not likely. It would be expected that other components in the drive failed first causing this failure or the conditions of operating the unit lead to such a failure.

CONDITION:

Blown Soft Charge Resistor Fuses:

Cause 1: Excessive input power cycling:
The DC bus capacitors are charged by current flowing through the soft charge resistors. Due to the fact that current flowing through the soft charge resistors generates heat, excessive power cycling can overheat the resistors, cause the thermal switches to activate (close) and blow the resistor fuses. For this reason, input power cycling is limited to once every two minutes. Under normal circumstances the thermal switch will reset (open) once it cools down. The fuses can then be replaced and operation resumed.

Cause 2: SCR/Diode modules not conducting:
In this case all the power required by the inverter section must pass through the soft charge circuitry. The SCR's are controlled by the power card. A failure in the power card circuitry may be the cause or the cable connections from the power card to the gates of the SCR's. It could be possible that one or more of the SCR/Diode modules could be open but this type of failure is extremely rare. See the section on dynamic tests for more on testing the SCR/Diode modules. Refer to the SCR gate driver test cable instruction for further testing of SCR gate signals. (This is a service tool that can be used to ease the testing of SCR by breaking out the SCR wire harness that connects to the power card. This cable can be ordered separate 176F1430.)

Cause 3: Short circuit in the intermediate or inverter section:
In this case, as the DC bus is attempting to charge all the energy is being drawn away by the fault. For example: a shorted brake IGBT would be dumping the DC bus voltage into the external brake resistor as the DC bus is attempting to charge. Since the soft charge resistors can not sustain the amount of current flow that would be present in this situation, The resistors would overheat, the thermals would close and the fuses would blow. Other such faults could be that the DC bus is being taken to ground through defective DC bus capacitors or inverter IGBT's. See more on this fault in the procedure for statically testing the intermediate circuit.

CONDITION:

Blown Soft Charge Rectifier Fuses:

Cause 1: Shorted Soft Charge Rectifier:
This component failure, is most likely the result of a failure elsewhere in the soft charge circuitry. Possibly due to shorted soft charge resistors. It would be expected that the resistor fuses would blow following the failure of the resistor. See the section above for more details on the possible causes of failure.

CONDITION:

Shorted SCR/Diode Modules:

Cause 1: Shorted IGBT:
An IGBT failure, under short circuit conditions, draws extensive current across the input of the drive. If slow acting interrupting devices (circuit breaker or improper fusing) are installed external to the drive it is likely for an SCR/Diode module to short circuit following an IGBT failure.

Cause 2: Shorted Brake IGBT:
In this case the shorted brake IGBT is dumping the DC bus voltage into the external brake resistors. This will cause extensive current to be drawn across the input of the unit as the SCR/Diode modules attempt to resupply the DC bus. This should also result in an overheated brake resistor. The resistor overload device should open and remove power from the drive or open the circuit to the DB resistors themselves.

Testing the Inverter Section

Refer to Photos 2 through 6 for location of components and test points.

The inverter section is primarily made up of the six IGBT's used for switching the DC bus voltage to create the output to the motor. Depending on the size of the VLT 5000 the six IGBT's will be installed as two per module for a total of three modules or one per module for a total of six IGBT modules. The VLT 5200 and 5250 also have snubber boards with snubber diodes mounted on each set of two modules.

When testing the inverter section it is important to disconnect the motor leads. With them connected a short circuit in one phase will be read in the other phases making the diagnosis more difficult.

Step 1
Connect the positive (+) meter lead to the positive DC bus connection. Connect the negative (–) meter lead to terminals U, V and W in turn. Each reading should show infinity. In actuality the meter will start at a low value and slowly climb towards infinity due to capacitance within the drive being charged by the meter.

Incorrect Reading:
With the "Step 1" test connection the diodes in the positive IGBT's and negative snubber diodes are reverse biased so they are blocking current flow. If a short circuit exists, it would indicate the positive IGBT in the phase being tested is defective. In VLT 5200 and 5250 it could further indicate that the negative snubber diode in that same phase is shorted. To verify the faulty component it will be necessary to disassemble the unit and isolate the components. See the section on replacing IGBT's and snubber boards.

Step 2
Reverse the meter leads. Connect the negative (–) meter lead to the positive DC bus connection. Connect the positive (+) meter lead to U, V and W in turn. Each reading should show a diode drop.

Incorrect Reading:
With the "Step 2" test connection the diodes in the positive IGBT's and negative snubber diodes are forward biased so the meter reads the diode drop. If a short circuit exists, it would indicate the positive IGBT in the phase being tested is shorted. In VLT 5200 and 5250 it could further indicate that the negative snubber diode in the same phase is shorted. To verify the faulty component it will be necessary to disassemble the unit and isolate the components. See the section on replacing IGBT's and snubber boards.

Step 3
Connect the positive (+) meter lead to the negative DC bus connection. Connect the negative (–) meter lead to terminals U, V and W in turn. Each reading should show a diode drop.

Incorrect Reading:
With the "Step 3" test connection the diodes in the negative IGBT's and positive snubber diodes are forward biased so the meter reads the diode drop. If a short circuit exists it would indicate the negative IGBT in the phase being tested is defective. In VLT 5200 and 5250 it could further indicate that the positive snubber in that same phase is shorted. To verify the faulty component it will be necessary to disassemble the unit and isolate the components. See the section on replacing IGBT's and snubber boards.

Step 4
Reverse the meter leads. Connect the negative (–) meter lead to the negative DC bus connection. Connect the positive (+) meter lead to U, V and W in turn. Each reading should show infinity. The meter will move slowly towards infinity as it charges the capacitance within the drive.

Incorrect Reading:
With the "Step 4" test connection the diodes in the negative IGBT's and positive snubber diodes are reverse biased so they are blocking current flow. If a short circuit exists, it would indicate the negative IGBT in the phase being tested is defective. In VLT 5200 and 5250 it could further indicate that the positive snubber diode in the same phase is shorted. To verify the faulty component it will be necessary to disassemble the unit and isolate the components. See the section on replacing IGBT's and snubber boards.

Indications of a failure in this circuit:
An IGBT failure by itself is generally difficult to explain. In most cases the IGBT erupts, making it nearly impossible to conduct an analysis on the damaged device. IGBT failures may be caused by the drive being exposed to repeated short circuits or ground faults or operation of the unit outside of its normal operating parameters for extended periods of time. Following an IGBT failure it is important to verify the gate drive signals are present and of the correct waveshape. See the dynamic test section on checking IGBT gate signals.

Additional notes when troubleshooting the Inverter Section:
For VLT 5060-5100 a small gate board is soldered to the gate terminals of each IGBT. For VLT 5125-5150 the gate board is attached by screws to the gate terminals. The spare part IGBT is supplied with this board attached. Never replace just the IGBT without including a new gate board. For VLT 5200-5250 the gate board is part of the snubber card which mounts to one phase (two modules) via screws. The snubber board is not provided with spare part IGBT's but must always be tested if an IGBT is replaced. See the section on replacing IGBT's and snubber boards.

TESTING THE INTERMEDIATE SECTION

Refer to Photos 2 through 6 starting on page 30 for location of components and test points.

The Intermediate section is made up of the DC bus capacitors, the DC coils and the balance resistors across the capacitors. Also included in our tests of this section will be the Brake IGBT and Brake Snubber board if the unit is so equipped.

Step 1
Test for short circuits by setting an ohmmeter on the RX100 scale and read across the +DC and -DC terminals at the top of the capacitor bank. With the meter leads in one direction the meter will start out with low ohms and then move towards infinity as the meter charges the capacitors. Reversing the meter leads will then peg the meter at zero while the charge in the capacitors is discharged by the meter and then begin moving slowly towards infinity as the meter charges the capacitors in the reverse direction.

Although this test does not ensure the capacitors are fully functional it is a good test to ensure no short circuits exist in the intermediate circuit. A visual check can also be conducted. Check for vented capacitors, loose connections or damage to exterior of the capacitors.

Incorrect Reading:
If a short circuit were present and the unit is equipped with a brake perform the test of that circuit next.

A short circuit could further be caused by a short circuit in the soft charge, rectifier, or inverter section. Perform those tests as outlined in this chapter to isolate the cause of the short circuit. The only other likely cause would be a defective capacitor within the capacitor bank. The capacitor bank would then have to be removed and individual tests made to identify the defective component.

TESTING THE BRAKE IGBT

Step 2
Connect the positive (+) meter lead to the R– terminal and the negative (–) meter lead to the R+ terminal. The meter should read a diode drop.

Step 3
Reverse the meter leads, connecting the negative (–) meter lead to the R– terminal and the positive (+) meter lead to the R+ terminal. As with previous tests the meter will climb towards infinity as the meter charges the units internal capacitance.

Step 4
Connect the positive (+) meter lead to the R– terminal and the negative (–) meter lead to the DC– connection at the top of the capacitor bank. The meter will climb towards infinity as the units internal capacitance is charged by the meter.

Step 5
Reverse the meter leads, connecting the negative (–) meter lead to the R– terminal and the positive (+) meter lead to the DC– connection at the top of the capacitor bank. The meter should read a diode drop.

Incorrect Reading:
An incorrect reading from the previous 4 steps indicates a fault in the Brake IGBT. Be sure however that the previous tests of the Inverter, Rectifier, Soft Charge and Intermediate circuit have been performed. A failure in one of these sections could be read at this test since the brake IGBT is across the DC bus. See the section on replacing the Brake IGBT.

MISCELLANEOUS TESTS

Testing The Motor:
While making the various other static checks it is logical to make a resistance reading of the motor windings. Set the ohmmeter on the highest resistance scale. Read each of the motor leads, T1 (U), T2 (V), T3 (W) to ground. The reading should be infinity. Any reading at all indicates a breakdown in the motors insulation system or the wiring to the motor.

Test the phase to phase resistance of the motor. Set the ohmmeter on the lowest resistance scale. Read the phase to phase resistance on all three motor leads. Typical resistance readings on small motors such as 1 horsepower will only be in the range of 3 to 8 ohms. As the motors get larger the resistance decreases to a point that only precision measuring instruments can be used to make such a test. The main objective is to check for short circuits and not to verify a correct resistance reading for a particular motor. If that is your objective, please consult the motor manufacturer for the correct values.

A high voltage breakdown test should be conducted. This is normally done with a Megohmmeter, commonly referred to as a megger. This device is capable of suppling up to 500Volts as the resistance measurement is made. In contrast to a typical ohmmeter using a 1.5 or 9 VDC battery, a megger can detect insulation breakdowns far more accurately. When making such a test the motor leads must be disconnected from the VLT. Make the measurement at the wire nearest to the VLT. In this way all wiring, connections, and the motor windings will be captured by the test. Keep in mind all connections between drive and motor need to be closed or the testing will need to be done from each point in the circuit. Further isolation of components may be needed to determine which component is faulty. (Example motor verse wiring between drive and motor). Although the readings from motor leads to ground may vary based on the motor design, the amount of moisture in the windings, and the temperature of the motor it would be expected to see a reading of at least 500 Megohms or more.

Testing The Heatsink Temperature Sensor:
The temperature sensor is an NTC (Negative Temperature Coefficient) device. This means that when the temperature is low the resistance is high. As the temperature rises the resistance decreases. The power card reads the resistance of the device and makes decisions on fan speed and whether or not an over temperature condition exists. See the section on fan control for more on that subject.

The temperature sensor is rated as 10K ohms equals 25°C. The range of the sensors ohmic value is 787 ohms to 105K ohms with 787 ohms equal to 95°C. The easiest method to test the sensor is to separate the wire harness connector located just to the right of the capacitor bank. Read the resistance at the connector that is attached to the wires traveling under the capacitor bank. The resistance reading must correspond to the values described above. You can also test the signal from the heatsink thermal sensor while the drive is powered up. Refer to the signal board instruction manual on how to calculate heatsink temp. from the voltage feedback signal on the power card. (This service tool can be used to breakout different signals located on the power card to verify operation of the drive. This board can be ordered separate 176F1429.)

FAN TEST
Continuity test

NOTE: All continuity checks are made using an ohmmeter set to Rx1 scale. Digital or analog ohmmeters can be used.

1. Measure the connections from the autotransformer by measuring from L3 (T) to terminal 1 of the autotransformer. A reading of <1ohm should be indicated.

2. measure from L2 (S) to terminal 3 of the autotransformer. <1 ohm should be read.

3. measure from terminal 2 of the autotransformer to the black lead of the fan motor. <1 ohm should be read.

4. Measure between terminals 1 and 3 of the autotransformer. Approximately 60 ohms should be read.

5. Measure between terminals 1 and 2 of the autotransformer. Approximately 25 ohms should be read.

6 Measure between terminals 2 and 3 of the autotransformer. Approximately 35 ohms should be read.

7. Measure the black lead of the fan motor to the blue lead of the capacitor. <1 oh should be read.

8. Measure the brown lead of the fan motor to the brown lead of the capacitor. <1 ohm should be read.

9. Measure between the two leads of the capacitor (blue & brown). A capacitor charging effect should be seen.

Voltage Checks
To ensure that the autotransformer and control circuitry is operating correctly, the voltage supplied by the transformer to the fan should be measured. To perform this check a voltmeter capable of measuring up to 250 VAC and the signal test board(176F1429) should be used.

Connect the voltmeter to the black and blue leads of the fan motor. Install the signal test board into the test connector socket in the VLT according to the instructions.

Voltage checks should be taken at high and low speeds. High-speed operation can be controlled by the fan test switch on the signal test board. The fan will run at the low speed for a few seconds when the VLT is powered up.

Voltage at high speed - 230 VAC
Voltage at low speed - 165 VAC

Testing The Inductor Temperature Sensor:
Only VLT 5125-5250 NEMA 12/IP54 units are equipped with this sensor. The sensor is physically mounted on the lamination surface of the output inductor or on the left side of the cap bank depending on age of drive. It is a simple normally closed switch that opens when the surface of the inductor reaches 135°C. The sensor itself is an enclosed device but a measurement can be taken by separating the cable connector located just inches from the sensor.

With an ohmmeter probe the two pins in the connector checking for a short circuit. This would indicate the switch is closed as it is normally suppose to be. If the switch were open it has either reached its trip temperature and has not yet reset, or it is defective.

Photo 2: Actual photo of VLT 5150 Chassis/NEMA 1, VLT 5060-5250 Chassis/NEMA 1 Units are similar.

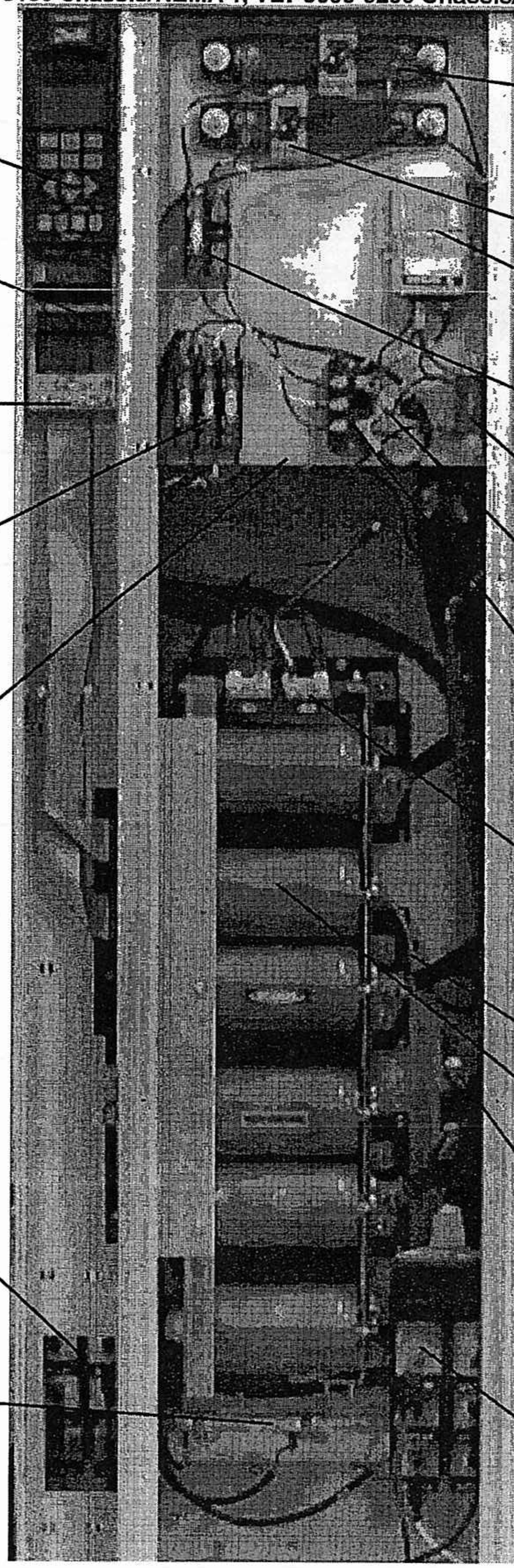


Photo 3: Actual photo of VLT 5100 NEMA 12, VLT 5060 and 5075 NEMA 12 units are similar.

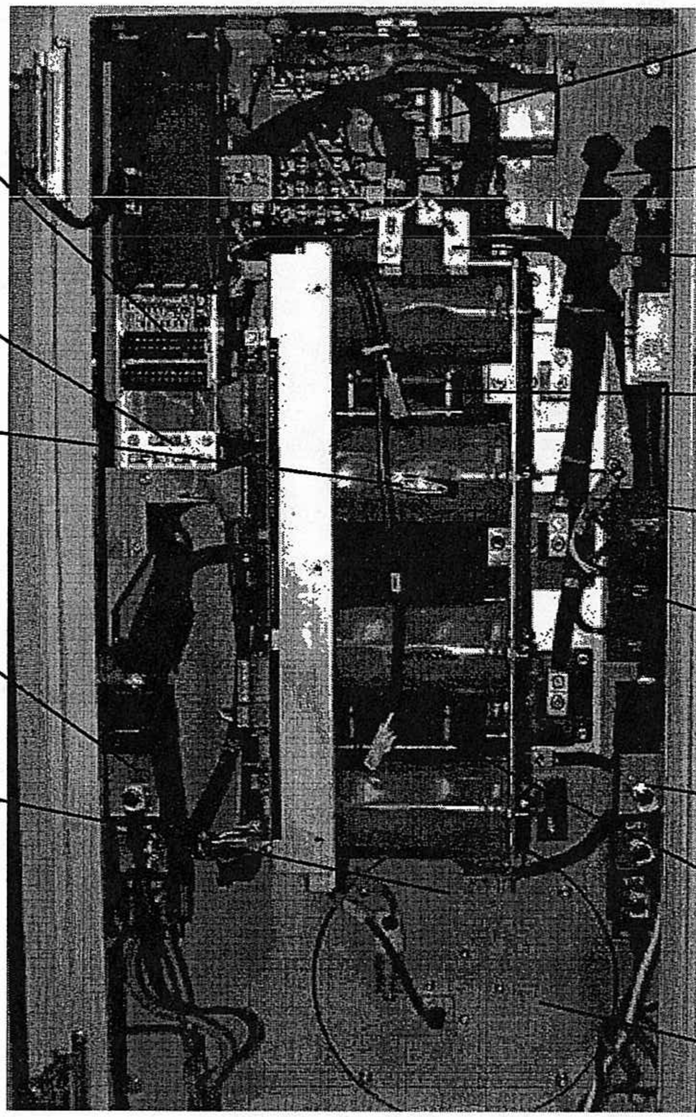


Photo 4: Actual photo of VLT 5100 NEMA 12 with + and – DC Bus wires removed for clarity. VLT 5060 and 5075 NEMA 12 units are similar.

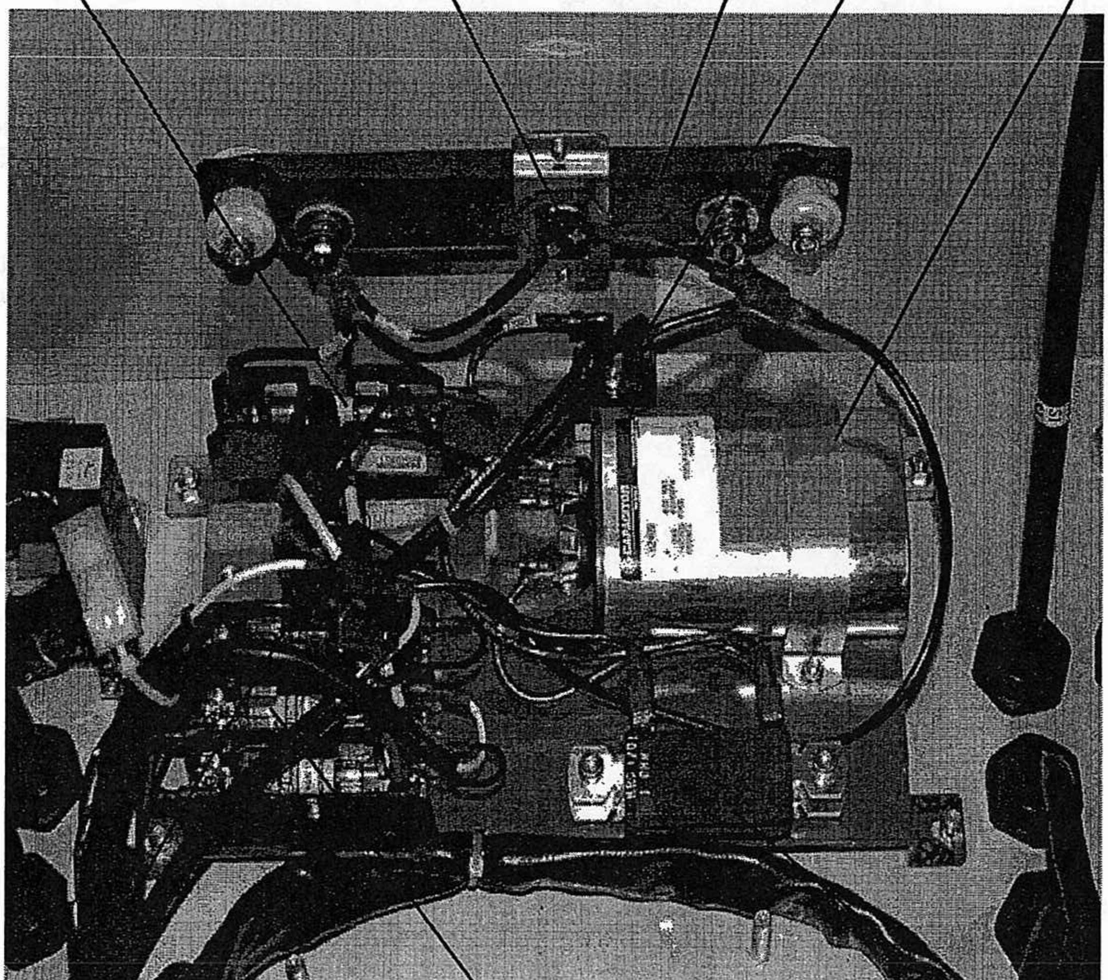


Photo 5: Actual photo of VLT 5200 NEMA 12, VLT 5125-5250 NEMA 12 units are similar.

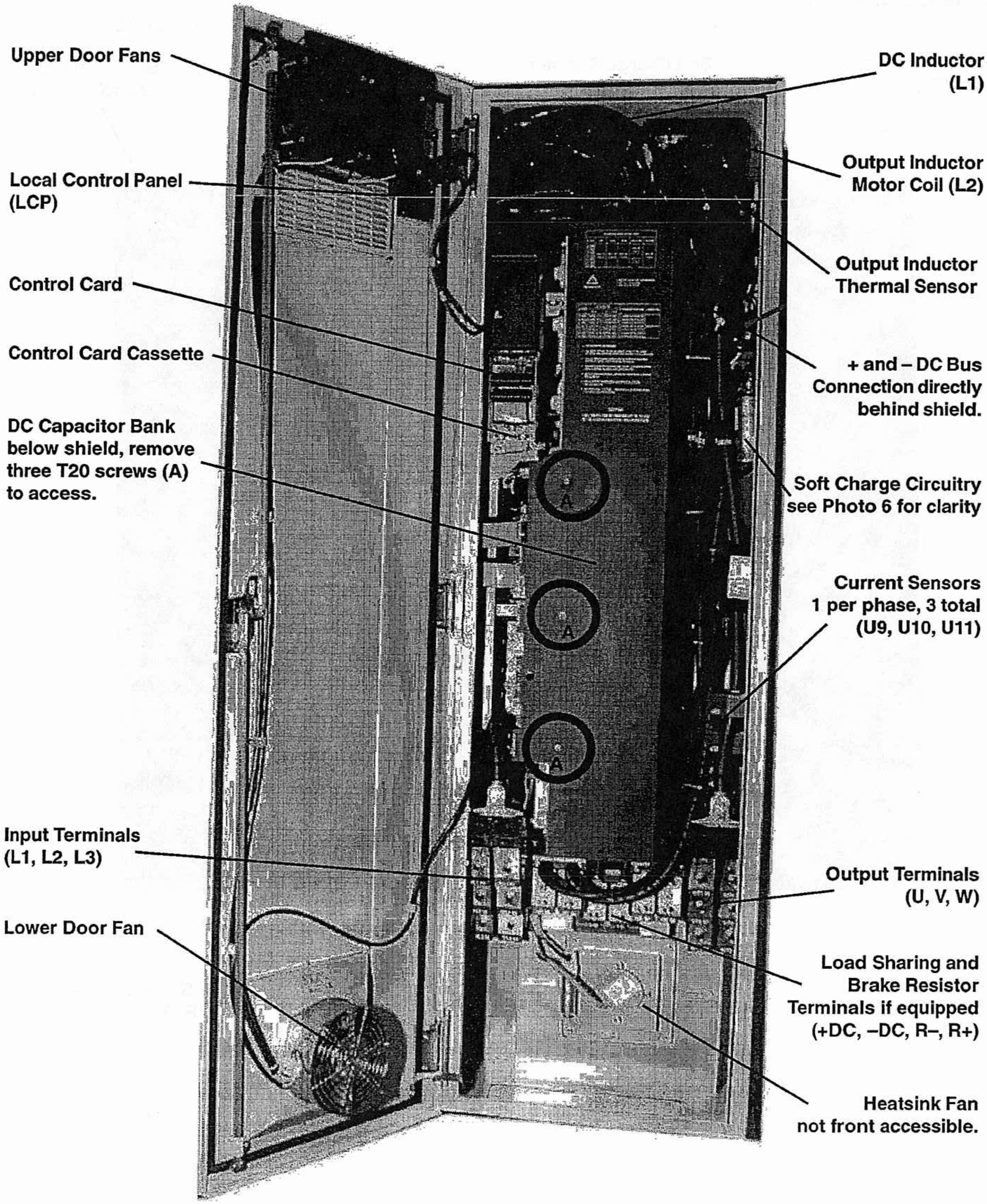
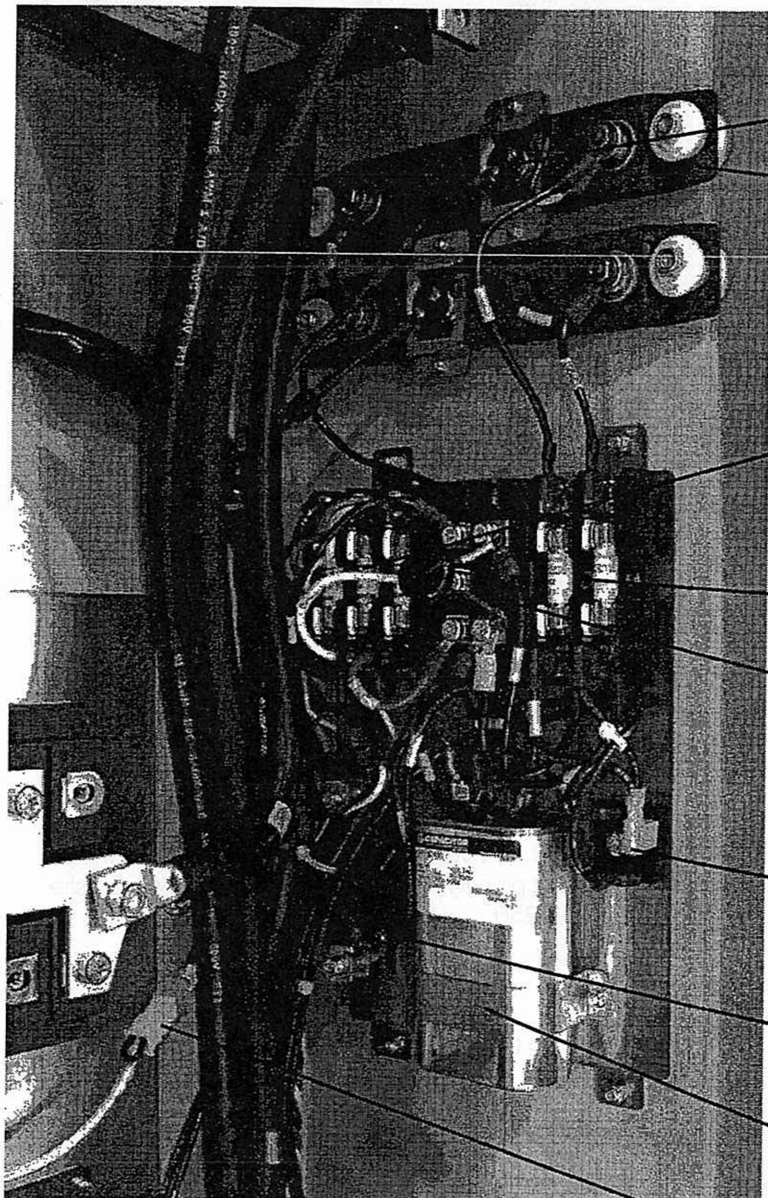


Photo 6: Actual photo of VLT 5200 NEMA 12 with Capacitor Bank removed. VLT 5125-2550 NEMA 12 units are similar.



DYNAMIC TEST PROCEDURES

Testing For Output Phase Imbalance

Checking the balance of the output voltage and current can give you an indication of whether or not the VLT is functioning correctly. When testing the output, both voltage and current are monitored. If the voltage is balanced but the current is not, It indicates the motor is drawing an uneven load. This could be the result of a defective motor, defective contacts in an overload conductor, or a poor connection in the wires feeding the motor. If the output current is unbalanced as well as the voltage, then the indication is the VLT is not gating the output properly. This could be the result of a defective power card, the connections from the power card to the IGBT's, or a poor connection within the VLT.

The voltage tests can be made with the motor connected however this is a good test to make following a repair, prior to connecting the motor wires. Further more it would be typical that if both output voltage and current were unbalanced the VLT would most likely be tripping on an over current fault when attempting to run the load. The voltage test could then only be made with the motor leads disconnected.

NOTE: When monitoring output voltage use an analog voltmeter. Digital voltameters are sensitive to the waveform and switching frequency and commonly return erroneous readings.

Step 1
Remove AC input power to the VLT.

CAUTION: The DC bus capacitors remain charged for approximately 15 minutes following the removal of the main supply. Allow sufficient time for the capacitors to discharge before entering the unit. Test for the presence of bus voltage by connecting a voltmeter set to read 1000VDC to the terminals at the top of the capacitor bank, labeled +BUS and –BUS.

Step 2
Disconnect the motor leads from the output terminals of the VLT.

Step 3
If you have not yet run the static tests on the inverter section perform that procedure now.

Step 4
If the inverter section test is successful, apply main power to the VLT, initiate a run command with a speed greater than 40Hz.

Note: the speed of 40 Hz is only significant with regards to the clamp on device being used to read current. Some test equipment of this type is only specified to be accurate above a frequency of 40Hz.

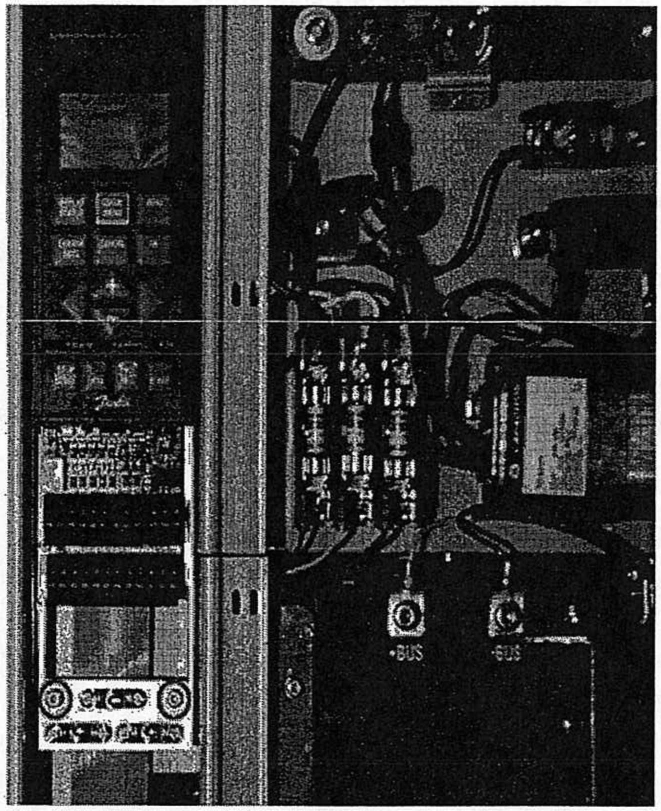


Photo 1

NOTE:

Photo is typical of a VLT 5060-5100 Chassis, others will be similar however, polarity of + and - bus connection is opposite on VLT 5125-5250.

Step 5
Read the phase to phase output voltage of all three phases. The actual value is less of a concern than the balance of all three phases. All three phases should be within 8VAC of each other. If a greater imbalance exists proceed to the Testing IGBT Gate Drive Signal section and check for loose connections within the drive.

Step 6
If the voltage is balanced, remove power, allow the DC bus to discharge, reconnect the motor, return to running at a speed close to or above 40Hz and monitor the output current of all three phases. The output current should be balanced within 2 to 3% of each other. If an imbalance exists, check for poor connections to the motor or the quality of the motor itself.

TESTING THE INPUT SCR/DIODE MODULES:

Theoretically the current drawn on each of the three input phases of the VLT should be equal. Some imbalance may be seen however due to variations in phase to phase input voltage and some single phase loads within the unit. Reference figure 8

A simple test of monitoring input current can be made to rule out any suspicion of a problem in this area but a more thorough test may be warranted if the SCR/Diode module or the gate signals are thought to be at fault.

Given that the input voltage is balanced, monitor the three input phases with a clamp on ampmeter. The current readings should be within 5% of each other. An imbalance of greater than 5% may indicate that either the input voltage is not balanced or the SCR/Diode modules are not conducting properly. If the latter is true this may be due to a defective power card, wiring connection from the power card to the devices or the SCR/Diode modules themselves.

One step would be to swap two of the input leads to verify if the imbalance follows or stays in the same phase of the drive. If the problem follows it is possible the input voltage supply should be in question. If the problem stays in the same phase proceed to verify proper SCR/Diode operation by monitoring the SCR/Diode gate signal.

Monitoring the actual SCR gate signals can be difficult depending on the specific model of VLT. In order to view the gate signal an oscilloscope and a current probe are required. The VLT must be running at some minimum load, at least above magnetizing current by 10 to 20%. An unloaded motor may not draw sufficient current to generate gate signals with adequate aplitude so they can be easily identified.

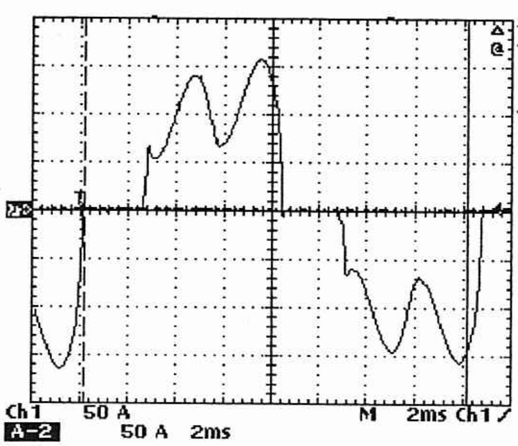


Figure 8

Typical input current wave form 5075 at 100 amp load

In most units the gate wiring and SCR/Diode modules are physically located below the capacitor bank. The only means to access the gate leads is through the use of the SCR gate lead break out wiring assembly. This assembly, available from Danfoss, inserts between the power card and the cable assembly from the SCR/Diode modules. On some units the SCR/Diode modules are located at the bottom of the unit and are easily accessed (see photo 7). For those units place the current probe around the white gate wire. With the unit running the SCR gate current should appear as in Figure 9:

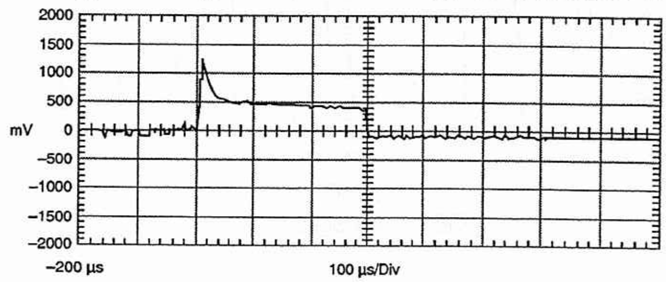


Figure 9
SCR Gate Signal

TESTING IGBT GATE DRIVE SIGNALS:

The gate drive signals, one for each IGBT for a total of six, originate on the control card. They are delivered to the power card, isolated, and then sent to each IGBT. A defective gate drive signal can cause an IGBT failure, over current trips, or an imbalance in the output of the VLT. Tripping caused by imbalances will most likely be the result of a gate drive signal missing completely. Any other form of distortion in one of the gating signals will normally result in a shorted IGBT. The signal board can be used to monitor these signals. As seen on the signal board, these signals are on the isolated side of the power card. A good signal here does not rule out a defective signal on the IGBT side of the power card. To test that portion of the signal it would be necessary to carry out the following procedure. The gate drive signals can be tested in two ways. One method is with the signal board allowing you to view the signal as it is distributed to the individual gate drivers on the power card. This is explained later in this section. However, following a repair it would be beneficial to monitor the gate drive signals directly at the gates of the IGBT's. This can only be carried out with the capacitor bank removed and the VLT powered by means of an external DC bus supply. Danfoss makes available such a power supply for making these measurements. Reference Appendix V Pages 94-97.

CAUTION: The gate drive signals are referenced to the negative DC bus. Line powered test equipment such as an oscilloscope must be isolated from ground when making measurements. Failure to do so will cause damage to the VLT. Also, depending on the method used to isolate the test equipment, the chassis of the test equipment may be at DC bus potential when connected to the VLT.

With the VLT powered by the external bus supply use an oscilloscope to monitor the gate drive signals. Place the unit in run with a speed reference of 0Hz. Connect the ground of the scopethe emitter (E) terminal of the IGBT. Place the probe on the gate (G) terminal of the IGBT(see photos 8,9,10). The signal should appear as in Figure 10:

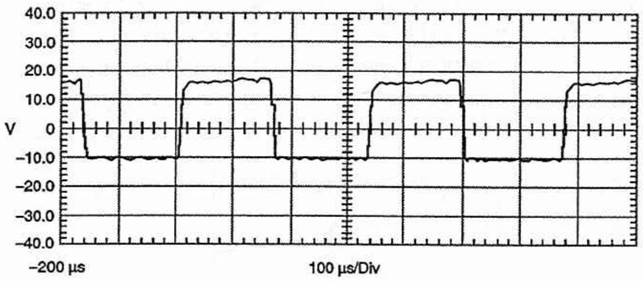


Figure 10
IGBT Gate Signal

Note: The waveform above was taken with the VLT 5000 carrier frequency set to 3.0Khz. Higher carrier frequencies will result in a waveform with a higher frequency.

Although an oscilloscope is the test instrument of choice in the absence of such equipment a volt meter can be used to obtain a reading that will give you a reasonable indication that the gate signals are functioning correctly. Set the volt meter to read 10VDC. Connect the positive (+) meter lead to the gate (G) terminal of the IGBT. Connect the negative (–) meter lead to the emitter (E) terminal of the IGBT. Place the VLT in run at 0Hz. The meter should read approximately 2 VDC. Compare all six gates to one another. If the readings are not similar further investigation is required.

NOTE:

The following signals will be monitored by use of the signal board. Danfoss makes available a signal board for ease of monitoring these signals.

TESTING FOR CURRENT FEEDBACK:

In each phase of the output resides a hall effect current sensor. These devices provide a current signal that is scaled down but proportional to the current being drawn by the output. The power card and the control card use this current feedback to make corrections to the waveform and protect the VLT from output short circuits and severe overload conditions. A defect in this circuit may also cause the VLT to erroneously trip on over current and ground fault alarms.

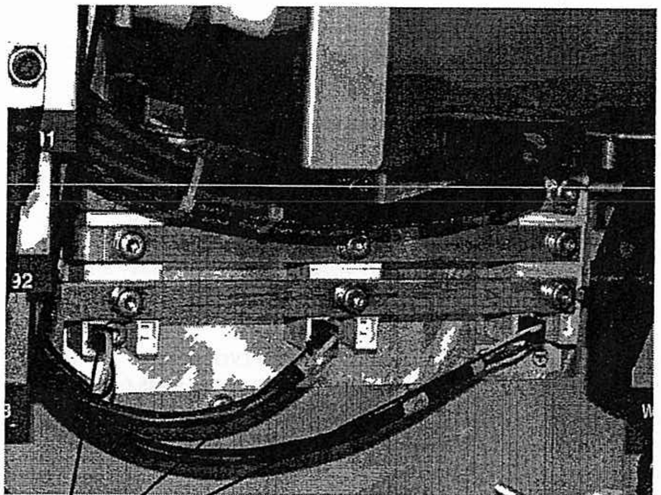
If you have verified that the application is not overloading the unit and the motor is not shorted phase to phase or to ground and the VLT still trips, you may want to conduct a test on current feedback. The signal from the current sensors are available on the signal board. Reference Appendix III Pages 81-91.

OTHER SIGNALS:

Many other signals can be monitored via the signal board. Among the signals that can be observed:

Low voltage power supplies; Fan speed control; Over voltage limits; Temperature trip signal; Brake control signal; Inrush control signal. See Appendix III for more on using the signal board.

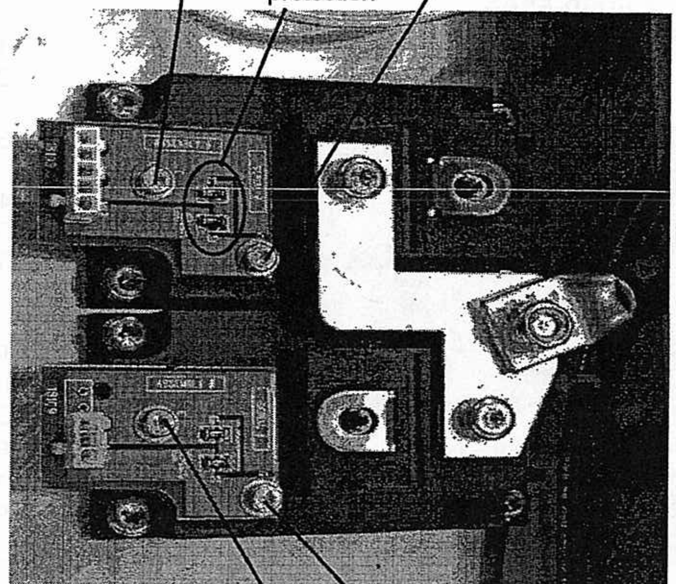
PHOTO 7
SCR Gate Connections
VLT 5125-5150



Gate signals

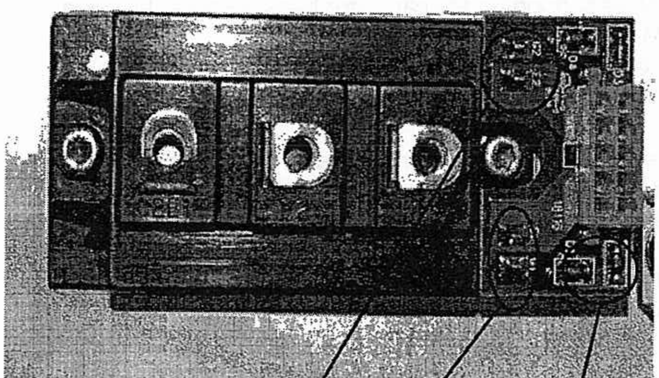
PHOTO 9
IGBT VLT 5125-5150

Emitter
Zenner Diodes
For gate transient protection
Gate



Emitter
Gate

PHOTO 8
IGBT VLT 5060-5100

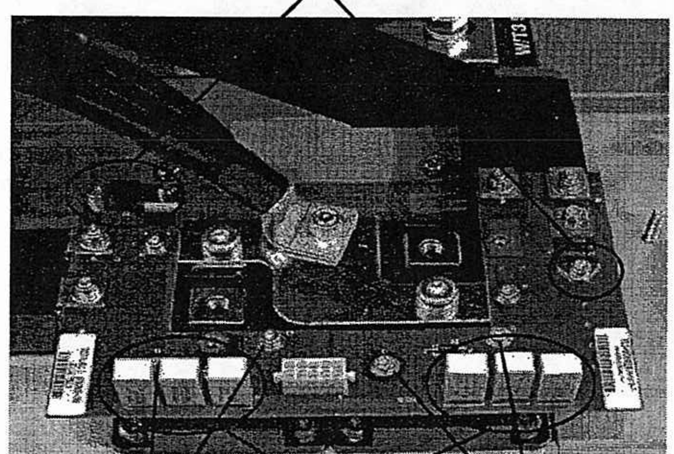


Emitter/Gate

Zener Diodes
For Gate Transient Protection

PHOTO 10
IGBT With Snubber Board
VLT 5200-5250

Snubber Diode



Emitter/Gate
Snubber Resistors
Emitter/Gate

SECTION FOUR

DISASSEMBLY INSTRUCTIONS

VLT 5060-5100
NEMA 12/IP54

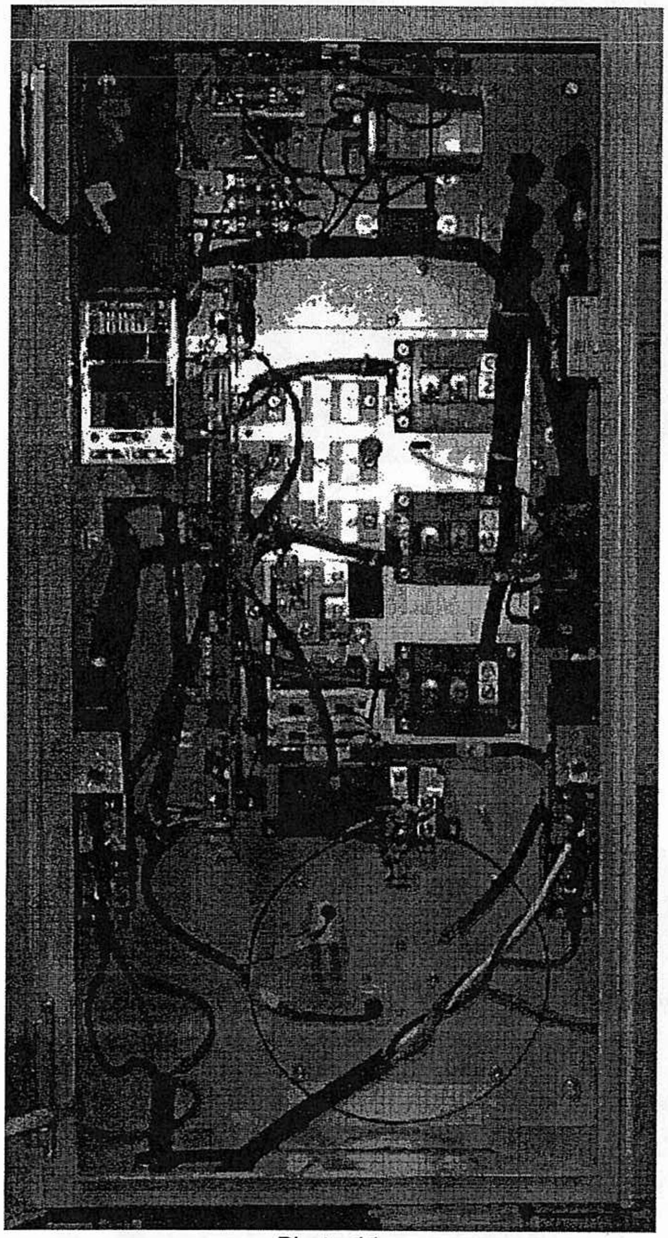


Photo 11

VLT 5060 - 5100 NEMA 12/IP54

Removing the control card:

Note: In Appendix II a quick reference to all Torque Specifications for the IGBT and SCR modules, throughout the disassembly section the torque specifications are referenced.

1. Disconnect the cable going to the local control panel.
2. Loosen the two T20 torx captive screws to free the cassette.
3. Lift the cassette from the bottom until its approximately at a 45° angle.
4. Unplug the two ribbon cables from the control card.
5. Push the cassette upwards to free it from the top hooks.
6. To replace the control card follow the instructions included with the spare part.

To reinstall the control card reverse the procedure.
Torque specifications: T20 screws to 8 Lb-In (1 NM).
Cable placement: The ribbon cables are made such that when laid flat the correct cable will be aligned to the proper connector or as installed the top power card connector mates to the lower control card connector.

Removing the capacitor bank:

1. Remove the black shield covering the capacitor bank by removing the three T20 torx screws.
2. Remove the three T20 torx screws securing the grounding bracket to the power card.
3. Remove the two T30 torx screws from the +Bus and –Bus connections.
4. Unplug the capacitor bank fan cable from the power card.
5. Remove the six T30 torx screws from the cap bank to IGBT connections.
6. Remove the wires from the three M8 studs at the bottom of the capacitor bank.
7. While supporting the capacitor bank, remove the three M10 locknuts.
8. Carefully remove the capacitor bank from the VLT and set upright.

To reinstall the capacitor bank reverse the procedure.
Torque specifications:
T20 screws to 8 Lb-In (1 NM)
T30 screws for IGBT's 35 Lb-In (4 NM)
T30 screws for + and –Bus 27 lb-In (3 NM)
M8 locknuts to 16 Lb-In (2 NM)
M10 locknuts to 27 Lb-In (3 NM)
Cable placement: Reconnect the wires to the studs at the bottom of the capacitor bank. First connect the white wire to the center stud. The shorter black wire from that same cable assembly connects to the inner most stud and the longer black wire to the outer most stud. If a brake is installed in the VLT then there will also be a 10 gauge wire attached to the inner most stud and a 4 gauge wire attached to the outer most stud. Reconnect the capacitor bank fan cable to connector MK 7 on the power card.

Removing the power card:

1. Unplug the three cable assemblies that attach to the IGBT's. If a brake is installed there will be 4.
2. Unplug the DC bus supply cable.
3. Remove the M10 locknut from the top of the power card mounting bracket to the heatsink.
4. Tilt the power card towards the middle of the unit and remove the connectors.
5. Lift the power card from the VLT.

Note: If the power card is being replaced you must remove the power card mounting bracket from the power card. A new bracket is not supplied with the spare part. The bracket is secured to the power card by means of two T20 screws and 2 nylon swags.

To reinstall the power card reverse the procedure.
Torque specifications: M10 locknuts to 27 Lb-In (3 NM).
Cable placement: As the power card is installed the gate cable assemblies align to the IGBT's from top to bottom. If a brake is installed the bottom cable attaches to the brake IGBT. Connect MK6, MK11 and MK12. The style and arrangement of the cables makes it impossible to make an incorrect connection. Connect the two ribbon cables from the control card. The top power card connector mates to the lower control card connector. Connect the DC bus supply cable to the mating connector. MK7 will be connected after the capacitor bank is reinstalled.

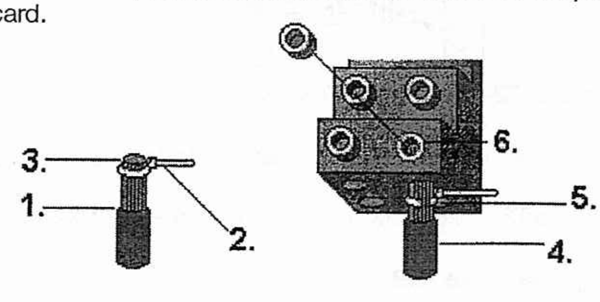
Removing the current sensors:

The spare current sensor assembly is provided as a complete unit with the three sensors, output terminals, splicer block, and wires all mounted on a common base plate. It is done in this way since the three current sensors have integrated leads that all combine into a common cable assembly within the VLT. It is also of prime importance that the correct sensor is placed in the right output phase. Providing the assembly in this way ensures correct placement of the sensors and makes installation easier.

1. Remove the motor leads from the output terminals.
2. Loosen the 3/16 hex screws in the splicer block to free the motor cables.
3. Unplug the heatsink thermal sensor connector from the cable harness.
4. Unplug the other end of the cable assembly at MK12 on the power card.
5. Cut any tie wraps securing the cable assembly.
6. Remove the four 7mm lock nuts securing the base plate to the VLT enclosure.
7. Remove the entire assembly

Note: For installing the wire into splicer block refer to photo below.

To reinstall the current sensor assembly reverse the procedure. Replace the tie wraps to secure the cable in place. Remember to reconnect the heatsink thermal sensor to the new cable harness and plug the cable harness into MK12 of the power card.



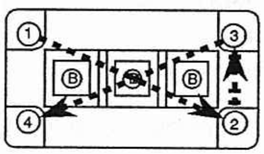
Torque the 7mm lock nuts to 16 Lb-In (2 NM).
Torque the 3/16 hex screws to 120 Lb-In (14 NM).

Removing the IGBT's:

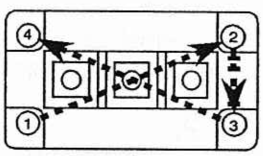
1. Remove the T30 torx screw that secures the output cable to the IGBT.
2. Remove the four T30 torx screws that secure the IGBT to the heatsink.
3. Do not remove the small circuit board mounted to the gate connections of the IGBT. The new spare part will be supplied with this circuit board attached.

Reinstalling the IGBT's:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the IGBT so the gate connections point towards the middle of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

6. Mount the output lead to the furthest terminal to the right on the IGBT.
7. Torque the T30 torx screw to 31-39 Lb-In (3.5-4.5 NM).

Removing the Brake IGBT:

1. Remove the two T30 torx screw that make the bus connection from the snubber card to the IGBT.
2. Remove the two T20 torx screws that make the gate connection from the snubber card to the IGBT..
3. Remove the T20 torx screw at the K1 position, remove the bus wire.
4. Remove the snubber card.
5. Remove the four T30 torx screws that secure the IGBT to the heatsink.
6. Remove the IGBT. Also remove the two M4 standoffs from the gate connections of the IGBT. The new spare part does not include these standoffs.

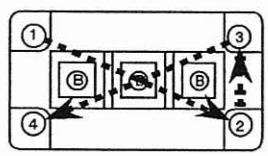
Now that the snubber board is removed this is a good time to check the components on the board to ensure they are functional.

Testing the Brake Snubber Board:

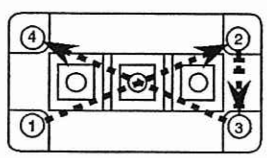
1. The two diodes, D1 and D2, provide transient suppression for the gate of the IGBT. With a VOM set to read diodes, measure the two diodes and look for a voltage drop in one direction, infinity in the other.
2. Resistors R1 - R6 are 1ohm resistors in parallel. Place an ohmmeter across terminal K1 and Cap 2. The resistance value will be equal to .16ohm. Most meters will not read this low resistance accurately so the important thing is to insure the resistance value is close without a short circuit or open being present.
3. The large diode on the board is the snubber diode. With a VOM set to read diodes measure the diode and look for a voltage drop in one direction, infinity in the other.

Reinstalling the Brake IGBT:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad on the heatsink.
3. Align the IGBT so the gate connections point towards the upper left hand side of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

6. Insert the M4 standoffs in the IGBT gate connections and torque to 13 Lb-In (1.5 NM).
7. Align the bus bars over the IGBT connections and place the snubber board on the IGBT.
8. Insert the two T30 screws in the power connections making sure the bus bar and IGBT connections are made. Torque to 35 Lb-In (4 NM).
9. Insert the two T20 screws, with washers, in the gate connections and torque to 13 Lb-In (1.5 NM).
10. Reconnect the bus wire to K1 with one T20 screw and torque to 13 Lb-In (1.5 NM).

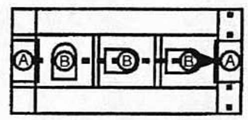
Removing the SCR/Diode modules:

1. Remove or loosen the six T30 torx screws that secure the bus bars to the top of the modules. Remove the input line connection to the failed or defective SCR.
2. Remove the two T30 torx screws that secure the module to the heatsink.
3. Unplug the gate connector from the module.

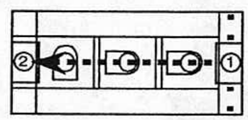
Reinstalling the SCR/Diode modules:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the module so the gate connections point towards the outside of the unit.
4. Insert the two T30 torx mounting screws, finger tight.
5. Torque the two T30 torx mounting screws following the pattern shown.
6. Insert the six bus bar screws and secure finger tight.
7. Torque each module following the patterns shown:
8. Plug the gate connector on to the module.

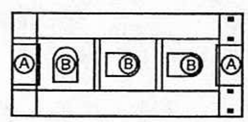
For VLT 5060 - 5075



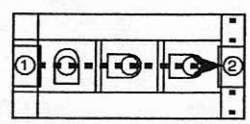
Tighten screws flush with the IGBT and torque initially to:
Torque A; 15 Lb-In (1.5 NM) Torque B; 9 Lb-In (1 NM)



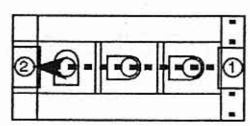
Final torque to:
Torque A; 44 Lb-In (5 NM) Torque B; 26 Lb-In (3 NM)



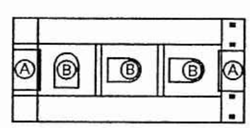
For VLT 5100



Tighten screws flush with the IGBT and torque initially to:
Torque A; 15 Lb-In (1.5 NM) Torque B; 9 Lb-In (1 NM)



Final torque to:
Torque A; 44 Lb-In (5 NM) Torque B; 44 Lb-In (5 NM)



DISASSEMBLY INSTRUCTIONS

VLT 5060 - 5100
CHASSIS/NEMA1/IP20

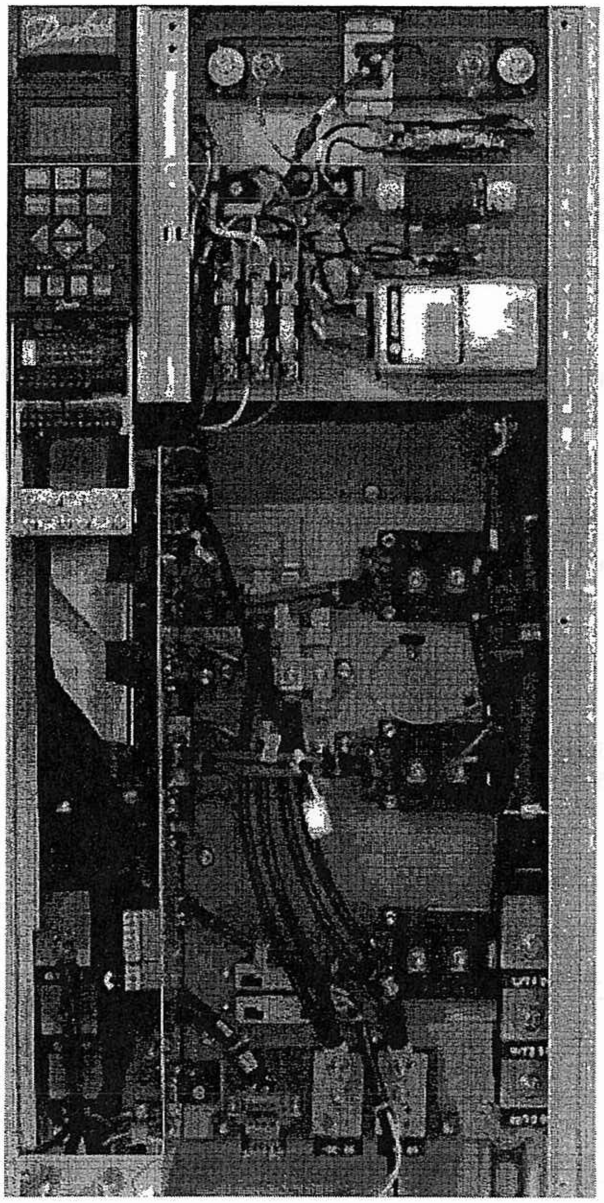


Photo 12

VLT 5060 - 5100 CHASSIS/NEMA 1/IP20

Removing the control card:

1. Disconnect the cable going to the local control panel.
2. Loosen the two T20 torx captive screws to free the cassette.
3. Lift the cassette from the bottom until its approximately at a 45° angle.
4. Unplug the two ribbon cables from the control card.
5. Push the cassette upwards to free it from the top hooks.
6. To replace the control card follow the instructions included with the spare part.

To reinstall the control card reverse the procedure.
Torque specifications: T20 screws to 8 Lb-In (1 NM).
Cable placement: The ribbon cables are made such that when laid flat the correct cable will be aligned to the proper connector or as installed the top power card connector mates to the lower control card connector.

Removing the cable tray:

On these units the removal of the capacitor bank and power card will be much easier if the control wiring cable tray is removed first.

1. Remove the black front plastic cover.
2. Remove the plexi-glass cover from the tray by removing the four T20 torx screws.
3. Remove the two bottom M10 standoffs.
4. Remove the T20 screw that secures the stiffener to the cable tray at the bottom of the unit.
5. Unplug the ribbon cables from the power card.
6. Remove the two T20 screws at the top of the cable tray.
7. The cable tray is now free. Rotate the right edge of the tray to the left and lift out the tray.

To reinstall the cable tray reverse the procedure. Torque the T20 and M10 hardware to 16 Lb-in or 1.8 NM.

Removing the capacitor bank:

1. Remove the three T28 torx screws securing the power card bracket to the capacitor bank.
2. Remove the three T20 torx screws securing the grounding bracket to the power card.
3. Remove the two T30 torx screws from the +Bus and –Bus connections.
4. Remove the six T30 torx screws from the cap bank to IGBT connections.
5. Remove the wires from the three M8 studs at the bottom of the capacitor bank.
6. While supporting the capacitor bank, remove the three M10 locknuts.
7. Carefully remove the capacitor bank from the VLT.

To reinstall the capacitor bank reverse the procedure.
Torque specifications:
T20 screws to 8 Lb-In (1 NM)
T30 screws for IGBT's 35 Lb-In (4 NM)
T30 screws for + and –Bus 27 lb-In (3 NM)
M8 locknuts to 16 Lb-In (2 NM)
M10 locknuts to 27 Lb-In (3 NM)
Cable placement: Reconnect the wires to the studs at the bottom of the capacitor bank. First connect the white wire to the center stud. The shorter black wire from that same cable assembly connects to the inner most stud and the longer black wire to the outer most stud. If a brake is installed in the VLT then there will also be a 10 gauge wire attached to the inner most stud and a 4 gauge wire attached to the outer most stud.

Removing the power card:

1. Unplug the three cable assemblies that attach to the IGBT's. If a brake is installed there will be 4.
2. Unplug the DC bus supply cable.
3. Remove the M10 locknut from the top of the power cord mounting bracket to the heat sink.
4. Tilt the power card towards the middle of the unit and remove the connectors.
5. Lift the power card from the VLT.

Note: If the power card is being replaced you must remove the lower mounting bracket from the power card. A new bracket is not supplied with the spare part. The bracket is secured to the power card by means of two T20 screws and 2 nylon swags.

To reinstall the power card reverse the procedure.
Torque specifications: M10 locknuts to 27 Lb-In (3 NM).
Cable placement: As the power card is installed the gate cable assemblies align to the IGBT's from top to bottom. If a brake is installed the bottom cable attaches to the brake IGBT. Connect MK6, MK11 and MK12. The style and arrangement of the cables makes it impossible to make an incorrect connection. Connect the two ribbon cables from the control card. The top power card connector mates to the lower control card connector. Connect the DC bus supply cable to the mating connector.

Removing the current sensors:

The spare current sensor assembly is provided as a complete unit with the three sensors, output terminals, and wires all mounted on a common base plate. It is done in this way since the three current sensors have integrated leads that all combine into a common cable assembly within the VLT. It is also of prime importance that the correct sensor is placed in the right output phase. Providing the assembly in this way ensures correct placement of the sensors and makes installation easier.

1. Remove the motor leads from the output terminals.
2. Remove the T30 torx screws securing the 3 internal motor cables to the output inductor.
3. Unplug the heatsink thermal sensor connector from the cable harness.
4. Unplug the other end of the cable assembly at MK12 on the power card.
5. Cut any tie wraps securing the cable assembly.
6. Remove the four 7mm lock nuts securing the base plate to the VLT enclosure.
7. Remove the entire assembly

To reinstall the current sensor assembly reverse the procedure. Replace the tie wraps to secure the cable in place. Remember to reconnect the heatsink thermal sensor to the new cable harness and plug the cable harness into MK12 of the power card.

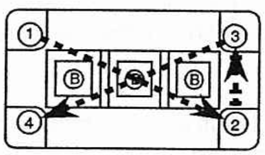
Torque the 7mm lock nuts to 16 Lb-In (2 NM).
Torque the T30 Torx screws to 27 Lb-In (3 NM).

Removing the IGBT's:

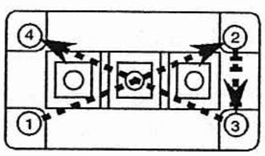
1. Remove the T30 torx screw that secures the output cable to the IGBT.
2. Remove the four T30 torx screws that secure the IGBT to the heatsink.
3. Do not remove the small circuit board mounted to the gate connections of the IGBT. The new spare part will be supplied with this circuit board attached.

Reinstalling the IGBT's:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the IGBT so the gate connections point towards the middle of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

6. Mount the output lead to the furthest terminal to the right on the IGBT.
7. Torque the T30 torx screw to 31-39 Lb-In (3.5-4.5 NM).

Removing the Brake IGBT:

1. Remove the two T30 torx screw that make the bus connection from the snubber card to the IGBT.
2. Remove the two T20 torx screws that make the gate connection from the snubber card to the IGBT..
3. Remove the T20 torx screw at the K1 position, remove the bus wire.
4. Remove the snubber card.
5. Remove the four T30 torx screws that secure the IGBT to the heatsink.
6. Remove the IGBT. Also remove the two M4 standoffs from the gate connections of the IGBT. The new spare part does not include these standoffs.

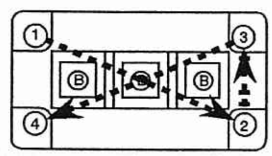
Now that the snubber board is removed this is a good time to check the components on the board to ensure they are functional.

Testing the Brake Snubber Board:

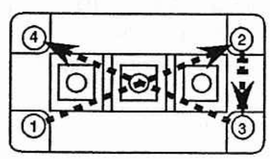
1. The two diodes, D1 and D2, provide transient suppression for the gate of the IGBT. With a VOM set to read diodes, measure the two diodes and look for a voltage drop in one direction, infinity in the other.
2. Resistors R1 - R6 are 1ohm resistors in parallel. Place an ohmmeter across terminal K1 and Cap 2. The resistance value will be equal to .16ohm. Most meters will not read this low resistance accurately so the important thing is to insure the resistance value is close without a short circuit or open being present.
3. The large diode on the board is the snubber diode. With a VOM set to read diodes measure the diode and look for a voltage drop in one direction, infinity in the other.

Reinstalling the Brake IGBT:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad on the heatsink.
3. Align the IGBT so the gate connections point towards the upper left hand side of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

6. Insert the M4 standoffs in the IGBT gate connections and torque to 13 Lb-In (1.5 NM).
7. Align the bus bars over the IGBT connections and place the snubber board on the IGBT.
8. Insert the two T30 screws in the power connections making sure the bus bar and IGBT connections are made. Torque to 35 Lb-In (4 NM).
9. Insert the two T20 screws, with washers, in the gate connections and torque to 13 Lb-In (1.5 NM).
10. Reconnect the bus wire to K1 with one T20 screw and torque to 13 Lb-In (1.5 NM).

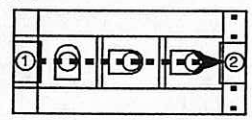
Removing the SCR/Diode modules:

1. Remove or loosen the six T30 torx screws that secure the bus bars to the top of the modules. Remove the input line connection to the failed or defective SCR.
2. Remove the two T30 torx screws that secure the module to the heatsink.
3. Unplug the gate connector from the module.

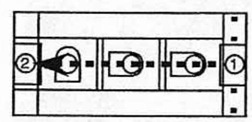
Reinstalling the SCR/Diode modules:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the module so the gate connections point towards the outside of the unit.
4. Insert the two T30 torx mounting screws, finger tight.
5. Torque the two T30 torx mounting screws following the pattern shown.
6. Insert the six bus bar screws and secure finger tight.
7. Torque each module following the patterns shown:
8. Plug the gate connector on to the module.

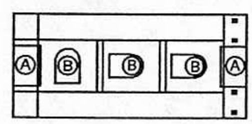
For VLT 5060 - 5075



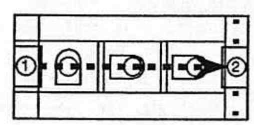
Tighten screws flush with the IGBT and torque initially to:
Torque A; 15 Lb-In (1.5 NM) Torque B; 9 Lb-In (1 NM)



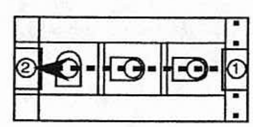
Final torque to:
Torque A; 44 Lb-In (5 NM) Torque B; 26 Lb-In (3 NM)



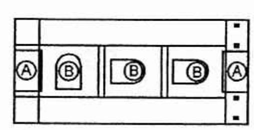
For VLT 5100



Tighten screws flush with the IGBT and torque initially to:
Torque A; 15 Lb-In (1.5 NM) Torque B; 9 Lb-In (1 NM)



Final torque to:
Torque A; 44 Lb-In (5 NM) Torque B; 44 Lb-In (5 NM)



DISASSEMBLY INSTRUCTIONS

VLT 5125 - 5150
NEMA 12/IP54

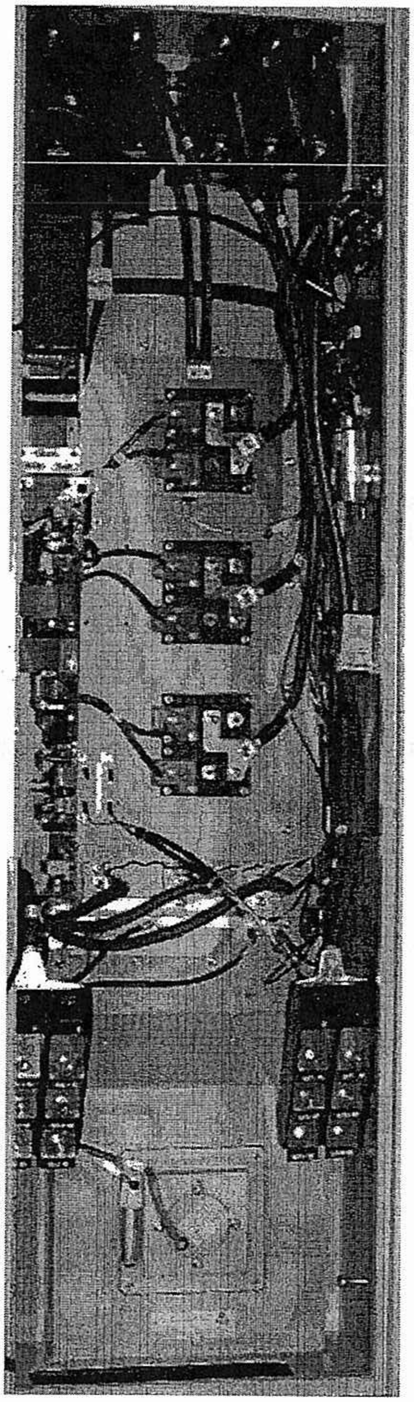


Photo 13

VLT 5125 - 5150 NEMA 12/IP54

Removing the control card:

1. Disconnect the cable going to the local control panel.
2. Loosen the two T20 torx captive screws to free the cassette.
3. Lift the cassette from the bottom until its approximately at a 45° angle.
4. Unplug the two ribbon cables from the control card.
5. Push the cassette upwards to free it from the top hooks.
6. To replace the control card follow the instructions included with the spare part.

To reinstall the control card reverse the procedure.
Torque specifications: T20 screws to 8 Lb-In (1 NM).
Cable placement: The ribbon cables are made such that when laid flat the correct cable will be aligned to the proper connector or as installed the top power card connector mates to the lower control card connector.

Removing the capacitor bank:

1. Remove the black shield covering the capacitor bank by removing the three T20 torx screws.
2. Remove the three T20 torx screws securing the grounding bracket to the power card.
3. Remove the four T30 torx screws from the +Bus and –Bus connections.
4. Remove the six T30 torx screws from the cap bank to IGBT connections.
5. Remove the wires from the three M8 studs at the bottom of the capacitor bank.
6. While supporting the capacitor bank, remove the four M10 locknuts.
7. Carefully remove the capacitor bank from the VLT and set upright.

To reinstall the capacitor bank reverse the procedure.
Torque specifications:
T20 screws to 8 Lb-In (1 NM)
T30 screws for IGBT's 35 Lb-In (4 NM)
T30 screws for + and –Bus 27 lb-In (3 NM)
M8 locknuts to 16 Lb-In (2 NM)
M10 locknuts to 27 Lb-In (3 NM)
Cable placement: Reconnect the wires to the studs at the bottom of the capacitor bank. First connect the white wire to the center stud. The shorter black wire from that same cable assembly connects to the inner most stud and the longer black wire to the outer most stud. If a brake is installed in the VLT then there will also be a 10 gauge wire attached to the inner most stud and a 4 gauge wire attached to the outer most stud.

Removing the power card:

1. Unplug the three cable assemblies that attach to the IGBT's. If a brake is installed there will be 4.
2. Unplug the DC bus supply cable.
3. Remove the M10 locknuts from the top and bottom of the power cord to the heat sink mounting bracket.
4. Tilt the power card towards the middle of the unit and remove the connectors.
5. Lift the power card from the VLT 5000.

Note: If the power card is being replaced you must remove the power cord mounting bracket from the power card. A new bracket is not supplied with the spare part. The bracket is secured to the power card by means of two T20 screws and 2 nylon swags.

To reinstall the power card reverse the procedure.
Torque specifications: M10 locknuts to 27 Lb-In (3 NM).
Cable placement: As the power card is installed the gate cable assemblies align to the IGBT's from top to bottom. If a brake is installed the bottom cable attaches to the brake IGBT. Connect MK6, MK11 and MK12. The style and arrangement of the cables makes it impossible to make an incorrect connection. Connect the two ribbon cables from the control card. The top power card connector mates to the lower control card connector. Connect the DC bus supply cable to the mating connector.

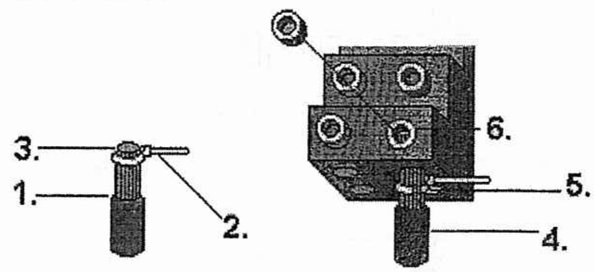
Removing the current sensors:

Each of the three current sensors is provided with a plug in connector so they can be replaced individually. It is of prime importance that if more than one sensor is removed, when installing the sensors ensure the correct cable is associated with the correct output phase.

1. Loosen the 3/16 hex screw securing the internal motor cable to the splicer block.
2. Unplug the wire connector at the current sensor.
3. Remove the two 8mm lock nuts securing the sensor to the base plate.
4. Slide the sensor off the end of the cable.

Note: For installing the wire into splicer block refer to photo below.

To reinstall the sensor reverse the procedure. Be sure the arrow on the top of the current sensor points towards the output of the VLT.



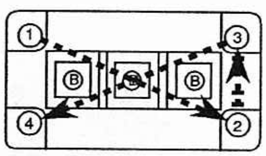
Torque the 8mm lock nuts to 16 Lb-In (2 NM)
Torque the 3/16 hex screws to 120 Lb-In (14 NM)

Removing the IGBT's:

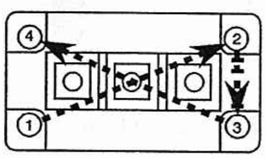
1. Remove the two T30 torx screw that secures the output cable to both upper and lower IGBT.
2. Remove the four T30 torx screws that secure the IGBT to the heatsink.
3. Do not remove the small circuit board mounted to the gate connections of the IGBT. The new spare part will be supplied with this circuit board attached.

Reinstalling the IGBT's:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the IGBT so the gate connections point towards the middle of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

6. Mount the output lead to the furthest terminal to the right on the IGBT. The lower IGBT will be mounted on the left terminal refer to photo 9.
7. Torque the T30 torx screw to 31-39 Lb-In (3.5-4.5 NM).

Removing the Brake IGBT:

1. Remove the two T30 torx screw that make the bus connection from the snubber card to the IGBT.
2. Remove the two T20 torx screws that make the gate connection from the snubber card to the IGBT..
3. Remove the two T20 torx screw at the K1 and K2 positions, remove the bus wire.
4. Remove the snubber card.
5. Remove the four T30 torx screws that secure the IGBT to the heatsink.
6. Remove the IGBT. Also remove the two M4 standoffs from the gate connections of the IGBT. The new spare part does not include these standoffs.

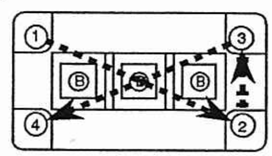
Now that the snubber board is removed this is a good time to check the components on the board to ensure they are functional.

Testing the Brake Snubber Board:

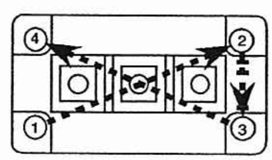
1. The two diodes, D1 and D2, provide transient suppression for the gate of the IGBT. With a VOM set to read diodes, measure the two diodes and look for a voltage drop in one direction, infinity in the other.
2. Resistors R1 - R9 are 1ohm resistors in parallel. Place an ohmmeter across terminal K1 and Cap 2. The resistance value will be equal to .11ohm. Most meters will not read this low resistance accurately so the important thing is to insure the resistance value is close without a short circuit or open being present.
3. The two large diodes on the board is the snubber diode. With a VOM set to read diodes measure the diode and look for a voltage drop in one direction, infinity in the other.

Reinstalling the Brake IGBT:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad on the heatsink.
3. Align the IGBT so the gate connections point towards the upper left hand side of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

6. Insert the M4 standoffs in the IGBT gate connections and torque to 13 Lb-In (1.5 NM).
7. Align the bus bars over the IGBT connections and place the snubber board on the IGBT.
8. Insert the two T30 screws in the power connections making sure the bus bar and IGBT connections are made. Torque to 35 Lb-In (4 NM).
9. Insert the two T20 screws, with washers, in the gate connections and torque to 13 Lb-In (1.5 NM).
10. Reconnect the bus wire to K1 and K2 with two T20 screws and torque to 13 Lb-In (1.5 NM).

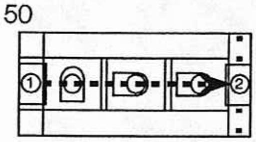
Removing the SCR/Diode modules:

1. Remove or loosen the six T30 torx screws that secure the bus bars to the top of the modules. Remove the input line connection to the failed or defective SCR.
2. remove the two T30 torx screws that secure the module to the heatsink.
3. Unplug the gate connector from the module.

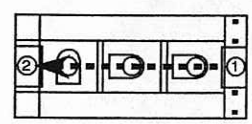
Reinstalling the SCR/Diode modules:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the module so the gate connections point towards the outside of the unit.
4. Insert the two T30 torx mounting screws, finger tight.
5. Torque the two T30 torx mounting screws following the pattern shown.
6. Insert the six bus bar screws and secure finger tight.
7. Torque each module following the patterns shown:
8. Plug the gate connector on to the module.

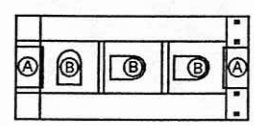
For VLT 5125-5150



Tighten screws flush with the IGBT and torque initially to:
Torque A; 15 Lb-In (1.5 NM) Torque B; 9 Lb-In (1 NM)



Final torque to:
Torque A; 44 Lb-In (5 NM) Torque B; 44 Lb-In (5 NM)



DISASSEMBLY INSTRUCTIONS

VLT 5125 - 5150 CHASSIS/NEMA1/IP20

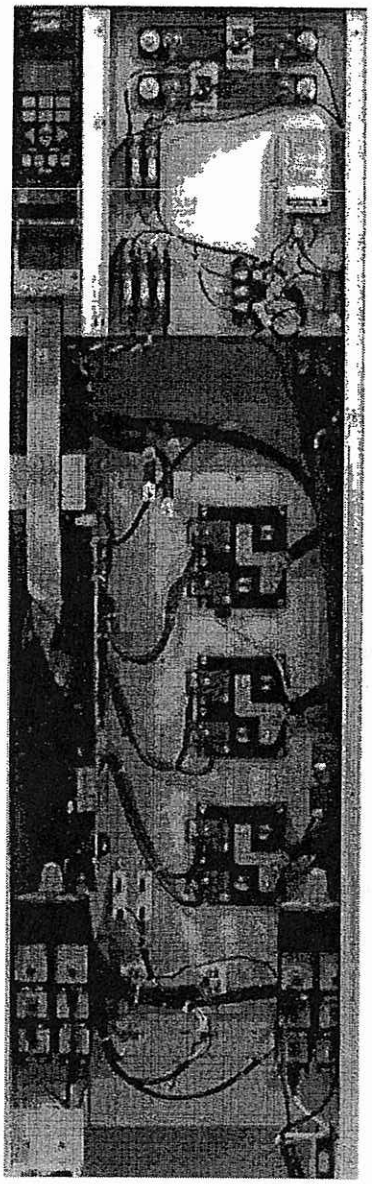


Photo 14

VLT 5125 - 5150 CHASSIS/NEMA 1/IP20

Removing the control card:

1. Remove the black front plastic piece.
2. Loosen the two T20 torx captive screws to free the cassette.
3. Lift the cassette from the bottom until its approximately at a 45° angle.
4. Unplug the two ribbon cables from the control card.
5. Push the cassette upwards to free it from the top hooks.
6. To replace the control card follow the instructions included with the spare part.

To reinstall the control card reverse the procedure.
Torque specifications: T20 screws to 8 Lb-In (1 NM).
Cable placement: The ribbon cables are made such that when laid flat the correct cable will be aligned to the proper connector or as installed the top power card connector mates to the lower control card connector.

Removing the cable tray:

On these units the removal of the capacitor bank and power card will be much easier if the control wiring cable tray is removed first.

1. Remove the black front plastic cover.
2. Remove the plexi-glass cover from the tray by removing the four T20 torx screws.
3. Remove the four M10 standoffs.
4. Remove the T20 screw that secures the stiffener to the cable tray at the bottom of the unit.
5. Unplug the ribbon cables from the power card.
6. Remove the two T20 screws at the top of the cable tray.
7. The cable tray is now free. Rotate the right edge of the tray to the left and lift out the tray.

To reinstall the cable tray reverse the procedure. Torque the T20 and M10 hardware to 16 Lb-in or 1.8 NM.

Removing the capacitor bank:

1. Remove the three T20 torx screws securing the power card bracket to the capacitor bank .
2. Remove the three T20 torx screws securing the grounding bracket to the power card.
3. Remove the four T30 torx screws from the +Bus and –Bus connections.
4. Remove the six T30 torx screws from the cap bank to IGBT connections.
5. Remove the wires from the three M8 studs at the bottom of the capacitor bank.
6. While supporting the capacitor bank, remove the four M10 locknuts.
7. Carefully remove the capacitor bank from the VLT.

To reinstall the capacitor bank reverse the procedure.
Torque specifications:
T20 screws to 8 Lb-In (1 NM)
T30 screws for IGBT's 35 Lb-In (4 NM)
T30 screws for + and –Bus 27 lb-In (3 NM)
M8 locknuts to 16 Lb-In (2 NM)
M10 locknuts to 27 Lb-In (3 NM)
Cable placement: Reconnect the wires to the studs at the bottom of the capacitor bank. First connect the white wire to the center stud. The shorter black wire from that same cable assembly connects to the inner most stud and the longer black wire to the outer most stud. If a brake is installed in the VLT then there will also be a 10 gauge wire attached to the inner most stud and a 4 gauge wire attached to the outer most stud.

Removing the power card:

1. Unplug the three cable assemblies that attach to the IGBT's. If a brake is installed there will be 4.
2. Unplug the DC bus supply cable.
3. Remove the M10 locknuts from the top and bottom of the power cord to the heat sink mounting bracket.
4. Tilt the power card towards the middle of the unit and remove the connectors.
5. Lift the power card from the VLT.

Note: If the power card is being replaced you must remove the lower mounting bracket from the power card. A new bracket is not supplied with the spare part. The bracket is secured to the power card by means of two T20 screws and 2 nylon swags.

To reinstall the power card reverse the procedure.
Torque specifications: M10 locknuts to 27 Lb-In (3 NM).
Cable placement: As the power card is installed the gate cable assemblies align to the IGBT's from top to bottom. If a brake is installed the bottom cable attaches to the brake IGBT. Connect MK6, MK11 and MK12. The style and arrangement of the cables makes it impossible to make an incorrect connection. Connect the two ribbon cables from the control card. The top power card connector mates to the lower control card connector. Connect the DC bus supply cable to the mating connector.

Removing the current sensors:

Each of the three current sensors is provided with a plug in connector so they can be replaced individually. It is of prime importance that if more than one sensor is removed, when installing the sensors ensure the correct cable is associated with the correct output phase.

1. Remove the T40 torx screw securing the internal motor to the output inductor.
2. Unplug the wire connector at the current sensor.
3. Remove the two 8mm lock nuts securing the sensor to the base plate.
4. Slide the sensor off the end of the cable.

To reinstall the sensor reverse the procedure. Be sure the arrow on the top of the current sensor points towards the output of the VLT.

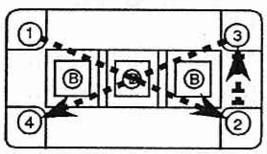
Torque the 8mm lock nuts to 16 Lb-In (2 NM)
Torque the T40 torx screw to 64 Lb-In (7.2 NM)

Removing the IGBT's:

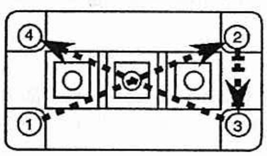
1. Remove the two T30 torx screw that secures the output cable to both upper and lower IGBT.
2. Remove the four T30 torx screws that secure the IGBT to the heatsink.
3. Do not remove the small circuit board mounted to the gate connections of the IGBT. The new spare part will be supplied with this circuit board attached.

Reinstalling the IGBT's:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the IGBT so the gate connections point towards the middle of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

6. Mount the output lead to the furthest terminal to the right on the IGBT. The lower IGBT will be anchored on the left terminal. Refer to photo 9.
7. Torque the T30 torx screw to 31-39 Lb-In (3.5-4.5 NM).

Removing the Brake IGBT:

1. Remove the two T30 torx screw that make the bus connection from the snubber card to the IGBT.
2. Remove the two T20 torx screws that make the gate connection from the snubber card to the IGBT..
3. Remove the two T20 torx screw at the K1 and K2 positions, remove the bus wire.
4. Remove the snubber card.
5. Remove the four T30 torx screws that secure the IGBT to the heatsink.
6. Remove the IGBT. Also remove the two M4 standoffs from the gate connections of the IGBT. The new spare part does not include these standoffs.

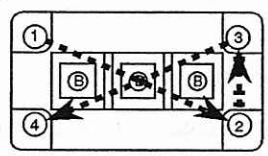
Now that the snubber board is removed this is a good time to check the components on the board to ensure they are functional.

Testing the Brake Snubber Board:

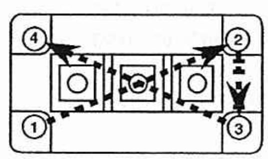
1. The two diodes, D1 and D2, provide transient suppression for the gate of the IGBT. With a VOM set to read diodes, measure the two diodes and look for a voltage drop in one direction, infinity in the other.
2. Resistors R1 - R9 are 1ohm resistors in parallel. Place an ohmmeter across terminal K1 and Cap 2. The resistance value will be equal to .11ohm. Most meters will not read this low resistance accurately so the important thing is to insure the resistance value is close without a short circuit or open being present.
3. The two large diodes on the board is the snubber diode. With a VOM set to read diodes measure the diode and look for a voltage drop in one direction, infinity in the other.

Reinstalling the Brake IGBT:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad on the heatsink.
3. Align the IGBT so the gate connections point towards the upper left hand side of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

6. Insert the M4 standoffs in the IGBT gate connections and torque to 13 Lb-In (1.5 NM).
7. Align the bus bars over the IGBT connections and place the snubber board on the IGBT.
8. Insert the two T30 screws in the power connections making sure the bus bar and IGBT connections are made. Torque to 35 Lb-In (4 NM).
9. Insert the two T20 screws, with washers, in the gate connections and torque to 13 Lb-In (1.5 NM).
10. Reconnect the bus wire to K1 and K2 with two T20 screws and torque to 13 Lb-In (1.5 NM).

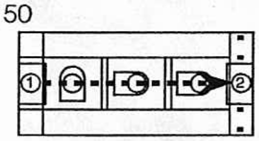
Removing the SCR/Diode modules:

1. Remove or loosen the six T30 torx screws that secure the bus bars to the top of the modules.
   Remove the input line connection to the failed or defective SCR.
2. Remove the two T30 torx screws that secure the module to the heatsink.
3. Unplug the gate connector from the module.

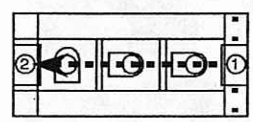
Reinstalling the SCR/Diode modules:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the module so the gate connections point towards the outside of the unit.
4. Insert the two T30 torx mounting screws, finger tight.
5. Torque the two T30 torx mounting screws following the pattern shown.
6. Insert the six bus bar screws and secure finger tight.
7. Torque each module following the patterns shown:
8. Plug the gate connector on to the module.

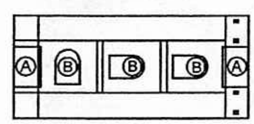
For VLT 5125-5150



Tighten screws flush with the IGBT and torque initially to:
Torque A; 15 Lb-In (1.5 NM) Torque B; 9 Lb-In (1 NM)



Final torque to:
Torque A; 44 Lb-In (5 NM) Torque B; 44 Lb-In (5 NM)



DISASSEMBLY INSTRUCTIONS

VLT 5200 - 5250
NEMA 12/IP54

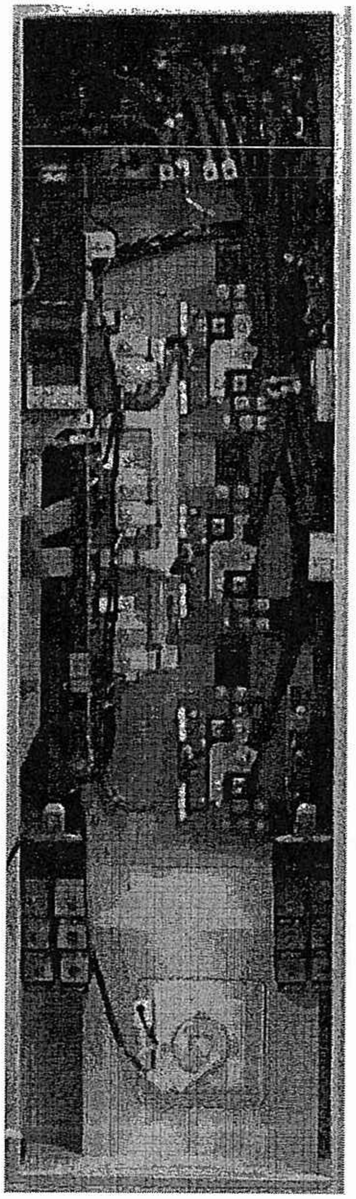


Photo 15

VLT 5200 - 5250 NEMA 12/IP54

Removing the control card:

1. Disconnect the cable going to the local control panel.
2. Loosen the two T20 torx captive screws to free the cassette.
3. Lift the cassette from the bottom until its approximately at a 45° angle.
4. Unplug the two ribbon cables from the control card.
5. Push the cassette upwards to free it from the top hooks.
6. To replace the control card follow the instructions included with the spare part.

To reinstall the control card reverse the procedure.
Torque specifications: T20 screws to 8 Lb-In (1 NM).
Cable placement: The ribbon cables are made such that when laid flat the correct cable will be aligned to the proper connector or as installed the top power card connector mates to the lower control card connector.

Removing the capacitor bank:

1. Remove the black shield covering the capacitor bank by removing the three T20 torx screws.
2. Remove the three T20 torx screws securing the grounding bracket to the power card.
3. Remove the four T30 torx screws from the +Bus and –Bus connections.
4. Remove the six T30 torx screws from the cap bank to IGBT connections.
5. Remove the six T20 torx screws from the cap bank to IGBT snubber board connections.
6. If a brake is installed, remove the wires from the three M8 studs at the bottom of the capacitor bank.
7. While supporting the capacitor bank, remove the four M10 locknuts.
8. Carefully remove the capacitor bank from the VLT.

NOTE: Now that the capacitor bank has been removed this is a good time to test the condition of the snubber boards.

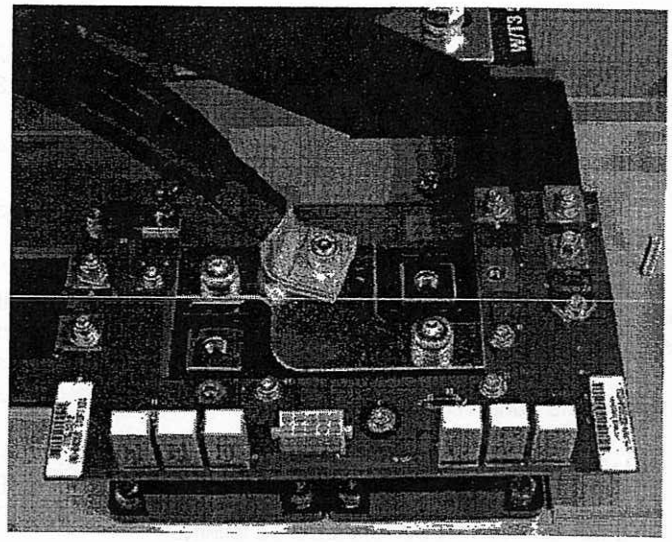


Photo 16

IGBT with Snubber Board VLT 5200 - 5250

Testing snubber boards:

Only in the VLT 5200 and 5250 is the snubber board a removable spare part. Part of this board are the snubber diodes, capacitors and resistors. Also found on the board are two smaller devices which appear to be diodes but are actually transorbs, transient suppression devices. These two transorbs are marked D3 and D4 and are placed across the gate of the IGBT to suppress transient energy. For this reason as soon as the snubber card is removed from the IGBT's the gates of the IGBT's should be shorted together to protect them from transient static electricity. Refer to photo 16.

Use a digital ohmmeter set on diode scale or an analog meter set on RX100.

Checking the snubber diodes, D1 and D2:

1. Connect the positive (+) meter lead to the large tab and the negative (–) meter lead to the small tab. The result should be a diode drop.
2. Reverse the meter leads, the reading should be infinity.
3. Repeat the same procedure on all the snubber diodes.

Should the diodes read incorrectly the entire snubber board is to be replaced. If a snubber diode is found shorted, the IGBT in that phase should also be replaced even if they have tested good. See "Removing the IGBT's".

Checking the transorbs, D3 and D4:

1. Set your ohmmeter to read on the highest scale. Check each device with the meter leads in one direction and then in the other. Both readings should be infinity.
2. Repeat this same procedure on all transorbs.

Should a transorb read incorrectly the entire snubber board is to be replaced. If a transorb is shorted it is likely that its corresponding IGBT is also defective. It too should be replaced. See "Removing the IGBT's".

To reinstall the capacitor bank reverse the procedure.
Torque specifications:
T20 screws for the IGBT's snubber board 14 Lb-In (2 NM)
Other T20 screws to 8 Lb-In (1 NM)
T30 screws for IGBT's 84 Lb-In (9.5 NM)
T30 screws for + and –Bus 27 lb-In (3 NM)
M8 locknuts to 16 Lb-In (2 NM)
M10 locknuts to 27 Lb-In (3 NM)
Cable placement: Reconnect the wires to the studs at the bottom of the capacitor bank. First connect the white wire to the center stud. The shorter black wire from that same cable assembly connects to the inner most stud and the longer black wire to the outer most stud. If a brake is installed in the VLT then there will also be a 10 gauge wire attached to the inner most stud and a 4 gauge wire attached to the outer most stud.

Removing the power card:

1. Unplug the three cable assemblies that attach to the IGBT's. If a brake is installed there will be 4.
2. Unplug the DC bus supply cable.
3. Remove the M10 locknuts from the top and bottom of the lower mounting bracket.
4. Tilt the power card towards the middle of the unit and remove the connectors.
5. Lift the power card from the VLT.

Note: If the power card is being replaced you must remove the power card mounting bracket from the power card. A new bracket is not supplied with the spare part. The bracket is secured to the power card by means of two T20 screws and 2 nylon swags.

To reinstall the power card reverse the procedure.
Torque specifications: M10 locknuts to 27 Lb-In (3 NM).
Cable placement: As the power card is installed the gate cable assemblies align to the IGBT's from top to bottom. If a brake is installed the bottom cable attaches to the brake IGBT. Connect MK6, MK11 and MK12. The style and arrangement of the cables makes it impossible to make an incorrect connection. Connect the two ribbon cables from the control card. The top power card connector mates to the lower control card connector. Connect the DC bus supply cable to the mating connector.

Removing the IGBT's:

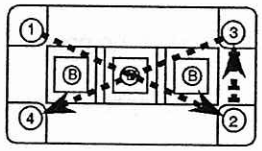
Caution: IGBT's are sensitive to static electricity. Once the snubber board is removed a jumper must be placed across the gate leads of the IGBT.

Note: If an IGBT is found defective ensure the snubber board has been tested as described above. Always replace both IGBT's in the damaged phase even if the other IGBT tested good.

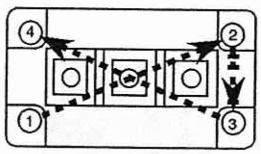
1. Remove the snubber board by removing the four T20 screws from the gate connections and the two T20 screws securing the board to the jumper bus bar.
2. Remove the two T30 torx screw that secure the bus bar jumper to the two IGBT's.
3. Remove the four T30 torx screws that secure the IGBT to the heatsink.

Reinstalling the IGBT's:

1. Remove the thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the IGBT so the gate connections point towards the middle of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 10 Lb-In (1.5 NM)



Final torque to 31-39 Lb-In (3.5-4.5 NM)

6. Mount the bus bar jumper to the two IGBT's. Reference photo 10.
7. Torque the T30 torx screws to 66-84 Lb-In (7.5-9.5 NM).
8. Install the snubber board aligning the wholes with the IGBT's.
9. Torque the 6 T20 screws to 12-15 Lb-In (1.3-1.7 NM).

Removing the Brake IGBT:

1. Remove the two T30 torx screw that make the bus connection from the snubber card to the IGBT.
2. Remove the two T20 torx screws that make the gate connection from the snubber card to the IGBT..
3. Remove the T20 torx screws at the K1, K2 and K3 positions, remove the bus wire.
4. Remove the snubber card.
5. Remove the four T30 torx screws that secure the IGBT to the heatsink.
6. Remove the IGBT. Also remove the two M4 standoffs from the gate connections of the IGBT. The new spare part does not include these standoffs.

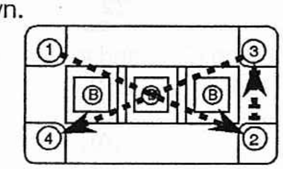
Now that the snubber board is removed this is a good time to check the components on the board to ensure they are functional.

Testing the Brake Snubber Board:

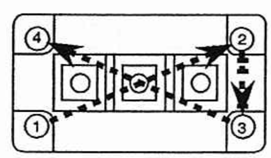
1. The two diodes, D1 and D2, provide transient suppression for the gate of the IGBT. With a VOM set to read diodes, measure the two diodes and look for a voltage drop in one direction, infinity in the other.
2. Resistors R1 - R12 are 1ohm resistors in parallel. Place an ohmmeter across terminal K1 and Cap 2. The resistance value will be equal to .08ohm. Most meters will not read this low resistance accurately so the important thing is to insure the resistance value is close without a short circuit or open being present.
3. The two large diodes on the board is the snubber diode. With a VOM set to read diodes measure the diode and look for a voltage drop in one direction, infinity in the other.

Reinstalling the Brake IGBT:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad on the heatsink.
3. Align the IGBT so the gate connections point towards the upper left hand side of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

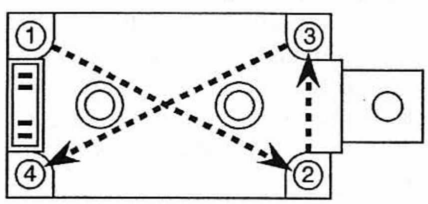
6. Insert the M4 standoffs in the IGBT gate connections and torque to 13 Lb-In (1.5 NM).
7. Align the bus bars over the IGBT connections and place the snubber board on the IGBT.
8. Insert the two T30 screws in the power connections making sure the bus bar and IGBT connections are made. Torque to 35 Lb-In (4 NM).
9. Insert the two T20 screws, with washers, in the gate connections and torque to 13 Lb-In (1.5 NM).
10. Reconnect the bus wire to K1 and K2 with two T20 screws and torque to 13 Lb-In (1.5 NM).

Removing the SCR/Diode modules:

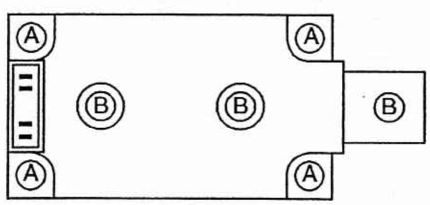
1. Remove or loosen the six T30 Drive Dependent torx screws that secure the bus bars to the top of the modules. Remove the input line connection to the failed or defective SCR.
2. Remove the additional T30 torx screws from the module being replaced.
3. Remove the four T30 torx screws that secure the module to the heatsink.
4. Unplug the gate connector from the module.
5. Slide the module out from under the bus bars.

Reinstalling the SCR/Diode modules:

1. Remove the thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the module so the gate connections point towards the bottom of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the mounting screws following the pattern shown.
6. Insert the six bus bar screws and secure finger tight.
7. Torque each module following the pattern below:



Tighten screws flush with the IGBT and torque initially to:
Torque A; 15 Lb-In (1.5 NM) Torque B; 26 Lb-In (3 NM)



Final torque to:
Torque A; 44 Lb-In (5 NM) Torque B; 80 Lb-In (9 NM)

8. Plug the gate connector on to the module.

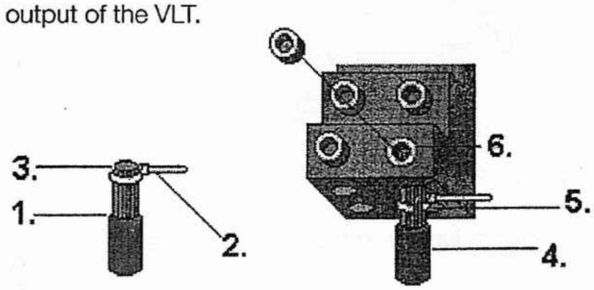
Removing the current sensors:

Each of the three current sensors is provided with a plug in connector so they can be replaced individually. It is of prime importance that if more than one sensor is removed, when installing the sensors ensure the correct cable is associated with the correct output phase.

1. Loosen the 5/16 (8mm) hex screw securing the internal motor cable to the splicer block.
2. Unplug the wire connector at the current sensor.
3. Remove the two 8mm lock nuts securing the sensor to the base plate.
4. Slide the sensor off the end of the cable.

Note: For installing the wire into splicer block refer to photo below.

To reinstall the sensor reverse the procedure. Be sure the arrow on the top of the current sensor points towards the output of the VLT.



Torque the 8mm lock nuts to 16 Lb-In (2 NM)
Torque the 5/16 (8mm) hex screws to 120 Lb-In (14 NM)

DISASSEMBLY INSTRUCTIONS

VLT 5200 - 5250 CHASSIS/NEMA1/IP20

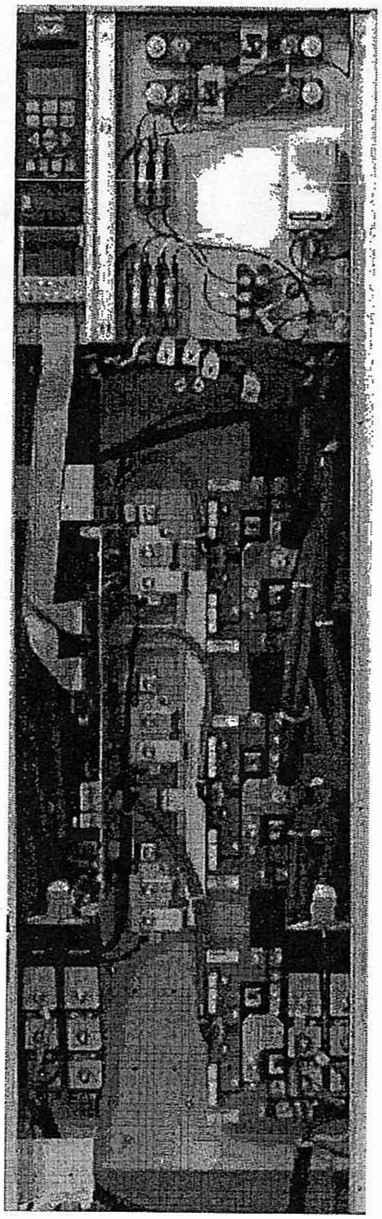


Photo 17

VLT 5200 - 5250 CHASSIS/NEMA 1/IP20

Removing the control card:

1. Remove the black front plastic piece.
2. Loosen the two T20 torx captive screws to free the cassette.
3. Lift the cassette from the bottom until its approximately at a 45° angle.
4. Unplug the two ribbon cables from the control card.
5. Push the cassette upwards to free it from the top hooks.
6. To replace the control card follow the instructions included with the spare part.

To reinstall the control card reverse the procedure.
Torque specifications: T20 screws to 8 Lb-In (1 NM).
Cable placement: The ribbon cables are made such that when laid flat the correct cable will be aligned to the proper connector or as installed the top power card connector mates to the lower control card connector.

Removing the cable tray:

On these units the removal of the capacitor bank and power card will be much easier if the control wiring cable tray is removed first.

1. Remove the black front plastic cover.
2. Remove the plexi-glass cover from the tray by removing the four T20 torx screws.
3. Remove the four M10 standoffs.
4. Remove the T20 screw that secures the stiffener to the cable tray at the bottom of the unit.
5. Unplug the ribbon cables from the power card.
6. Remove the two T20 screws at the top of the cable tray.
7. The cable tray is now free. Rotate the right edge of the tray to the left and lift out the tray.

To reinstall the cable tray reverse the procedure. Torque the T20 and M10 hardware to 16 Lb-in or 1.8 NM.

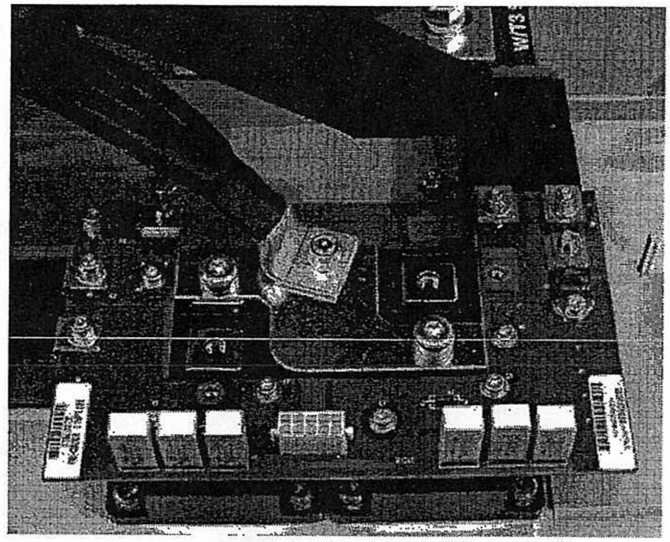
Removing the capacitor bank:

1. Remove the three T20 torx screws securing the power card to the capacitor bank.
2. Remove the three T20 torx screws securing the grounding bracket to the power card.
3. Remove the four T30 torx screws from the +Bus and –Bus connections.
4. Remove the six T30 torx screws from the cap bank to IGBT connections.
5. Remove the six T20 torx screws from the cap bank to the IGBT snubber board connections.
6. If a brake is installed, remove the wires from the three M8 studs at the bottom of the capacitor bank.
7. While supporting the capacitor bank, remove the four M10 locknuts.
8. Carefully remove the capacitor bank from the VLT and set upright.

NOTE: Now that the capacitor bank has been removed this is a good time to test the condition of the snubber boards.

Testing snubber boards:

Only in the VLT 5200 and 5250 is the snubber board a removable spare part. Part of this board are the snubber diodes, capacitors and resistors. Also found on the board are two smaller devices which appear to be diodes but are actually transorbs, transient suppression devices. These two transorbs are marked D3 and D4 and are placed across the gate of the IGBT to suppress transient energy. For this reason as soon as the snubber card is removed from the IGBT's the gates of the IGBT's should be shorted together to protect them from transient static electricity. Reference photo 18.



IGBT with Snubber Board VLT 5200 - 5250

Photo 18

Use a digital ohmmeter set on diode scale or an analog meter set on RX100.

Checking the snubber diodes, D1 and D2:

1. Connect the positive (+) meter lead to the large tab and the negative (–) meter lead to the small tab. The result should be a diode drop.
2. Reverse the meter leads, the reading should be infinity.
3. Repeat the same procedure on all the snubber diodes.

Should the diodes read incorrectly the entire snubber board is to be replaced. If a snubber diode is found shorted, the IGBT in that phase should also be replaced even if they have tested good. See "Removing the IGBT's".

Checking the transorbs, D3 and D4:

1. Set your ohmmeter to read on the highest scale. Check each device with the meter leads in one direction and then in the other. Both readings should be infinity.
2. Repeat this same procedure on all transorbs.

Should a transorb read incorrectly the entire snubber board is to be replaced. If a transorb is shorted it is likely that its corresponding IGBT is also defective. It too should be replaced. See "Removing the IGBT's".

To reinstall the capacitor bank reverse the procedure.
Torque specifications:
T20 screws for the IGBT's snubber board 14 Lb-In (2 NM)
Other T20 screws to 8 Lb-In (1 NM)
T30 screws for IGBT's 84 Lb-In (9.5 NM)
T30 screws for + and –Bus 27 lb-In (3 NM)
M8 locknuts to 16 Lb-In (2 NM)
M10 locknuts to 27 Lb-In (3 NM)
Cable placement: Reconnect the wires to the studs at the bottom of the capacitor bank. First connect the white wire to the center stud. The shorter black wire from that same cable assembly connects to the inner most stud and the longer black wire to the outer most stud. If a brake is installed in the VLT then there will also be a 10 gauge wire attached to the inner most stud and a 4 gauge wire attached to the outer most stud.

Removing the power card:

1. Unplug the three cable assemblies that attach to the IGBT's. If a brake is installed there will be 4.
2. Unplug the DC bus supply cable.
3. Remove the M10 locknuts from the top and bottom of the lower mounting bracket.
4. Tilt the power card towards the middle of the unit and remove the connectors.
5. Lift the power card from the VLT.

Note: If the power card is being replaced you must remove the lower mounting bracket from the power card. A new bracket is not supplied with the spare part. The bracket is secured to the power card by means of two T20 screws and 2 nylon swags.

To reinstall the power card reverse the procedure.
Torque specifications: M10 locknuts to 27 Lb-In (3 NM).
Cable placement: As the power card is installed the gate cable assemblies align to the IGBT's from top to bottom. If a brake is installed the bottom cable attaches to the brake IGBT. Connect MK6, MK11 and MK12. The style and arrangement of the cables makes it impossible to make an incorrect connection. Connect the two ribbon cables from the control card. The top power card connector mates to the lower control card connector. Connect the DC bus supply cable to the mating connector.

Removing the IGBT's:

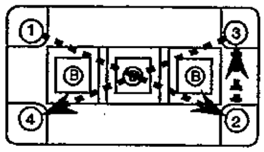
Caution: IGBT's are sensitive to static electricity. Once the snubber board is removed a jumper must be placed across the gate leads of the IGBT.

Note: If an IGBT is found defective ensure the snubber board has been tested as described above. Always replace both IGBT's in the damaged phase even if the other IGBT tested good.

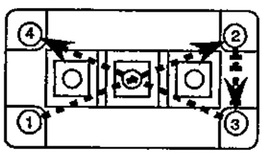
1. Remove the snubber board by removing the four T20 screws from the gate connections and the two T20 screws securing the board to the jumper bus bar.
2. Remove the two T30 torx screw that secure the bus bar jumper to the two IGBT's.
3. Remove the four T30 torx screws that secure the IGBT to the heatsink.

Reinstalling the IGBT's:

1. Remove the thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the IGBT so the gate connections point towards the middle of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 10 Lb-In (1.5 NM)



Final torque to 31-39 Lb-In (3.5-4.5 NM)

6. Mount the bus bar jumper to the two IGBT's. Reference photo 10.
7. Torque the T30 torx screws to 66-84 Lb-In (7.5-9.5 NM).
8. Install the snubber board aligning the wholes with the IGBT's.
9. Torque the 6 T20 screws to 12-15 Lb-In (1.3-1.7 NM).

Removing the Brake IGBT:

1. Remove the two T30 torx screw that make the bus connection from the snubber card to the IGBT.
2. Remove the two T20 torx screws that make the gate connection from the snubber card to the IGBT..
3. Remove the T20 torx screws at the K1, K2 and K3 positions, remove the bus wire.
4. Remove the snubber card.
5. Remove the four T30 torx screws that secure the IGBT to the heatsink.
6. Remove the IGBT. Also remove the two M4 standoffs from the gate connections of the IGBT. The new spare part does not include these standoffs.

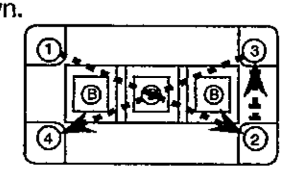
Now that the snubber board is removed this is a good time to check the components on the board to ensure they are functional.

Testing the Brake Snubber Board:

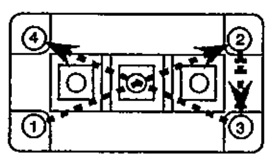
1. The two diodes, D1 and D2, provide transient suppression for the gate of the IGBT. With a VOM set to read diodes, measure the two diodes and look for a voltage drop in one direction, infinity in the other.
2. Resistors R1 - R12 are 1ohm resistors in parallel. Place an ohmmeter across terminal K1 and Cap 2. The resistance value will be equal to .08ohm. Most meters will not read this low resistance accurately so the important thing is to insure the resistance value is close without a short circuit or open being present.
3. The two large diodes on the board is the snubber diode. With a VOM set to read diodes measure the diode and look for a voltage drop in one direction, infinity in the other.

Reinstalling the Brake IGBT:

1. Remove the old thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad on the heatsink.
3. Align the IGBT so the gate connections point towards the upper left hand side of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the four T30 torx mounting screws following the pattern shown.



Tighten screws flush with the IGBT and torque initially to 9 Lb-In (1 NM)



Final torque to 22-30 Lb-In (2.5-3.5 NM)

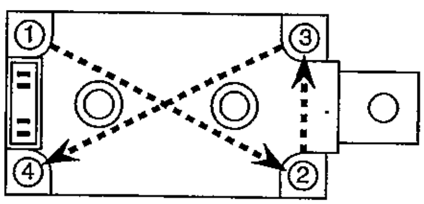
6. Insert the M4 standoffs in the IGBT gate connections and torque to 13 Lb-In (1.5 NM).
7. Align the bus bars over the IGBT connections and place the snubber board on the IGBT.
8. Insert the two T30 screws in the power connections making sure the bus bar and IGBT connections are made. Torque to 35 Lb-In (4 NM).
9. Insert the two T20 screws, with washers, in the gate connections and torque to 13 Lb-In (1.5 NM).
10. Reconnect the bus wire to K1 and K2 with two T20 screws and torque to 13 Lb-In (1.5 NM).

Removing the SCR/Diode modules:

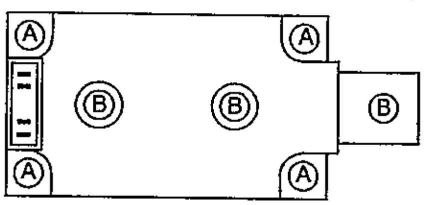
1. Remove or loosen the six T30 Drive Dependent torx screws that secure the bus bars to the top of the modules. Remove the input line connection to the failed or defective SCR.
2. Remove the additional T30 torx screws from the module being replaced.
3. Remove the four T30 torx screws that secure the module to the heatsink.
4. Unplug the gate connector from the module.
5. Slide the module out from under the bus bars.

Reinstalling the SCR/Diode modules:

1. Remove the thermal pad and insure the heatsink is free of dirt and remaining thermal compound.
2. Align the new thermal pad over the mounting holes in the heatsink.
3. Align the module so the gate connections point towards the bottom of the unit.
4. Insert the four T30 torx mounting screws, finger tight.
5. Torque the mounting screws following the pattern shown.
6. Insert the six bus bar screws and secure finger tight.
7. Torque each module following the pattern below:



Tighten screws flush with the IGBT and torque initially to:
Torque A; 15 Lb-In (1.5 NM) Torque B; 26 Lb-In (3 NM)



Final torque to:
Torque A; 44 Lb-In (5 NM) Torque B; 80 Lb-In (9 NM)

8. Plug the gate connector on to the module.

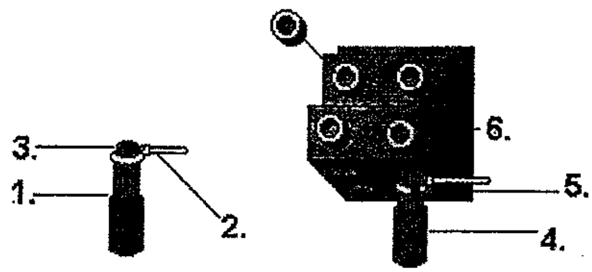
Removing the current sensors:

Each of the three current sensors is provided with a plug in connector so they can be replaced individually. It is of prime importance that if more than one sensor is removed, when installing the sensors ensure the correct cable is associated with the correct output phase.

1. Loosen the 5/16 (8mm) hex screw securing the internal motor cable to the splicer block.
2. Unplug the wire connector at the current sensor.
3. Remove the two 8mm lock nuts securing the sensor to the base plate.
4. Slide the sensor off the end of the cable.

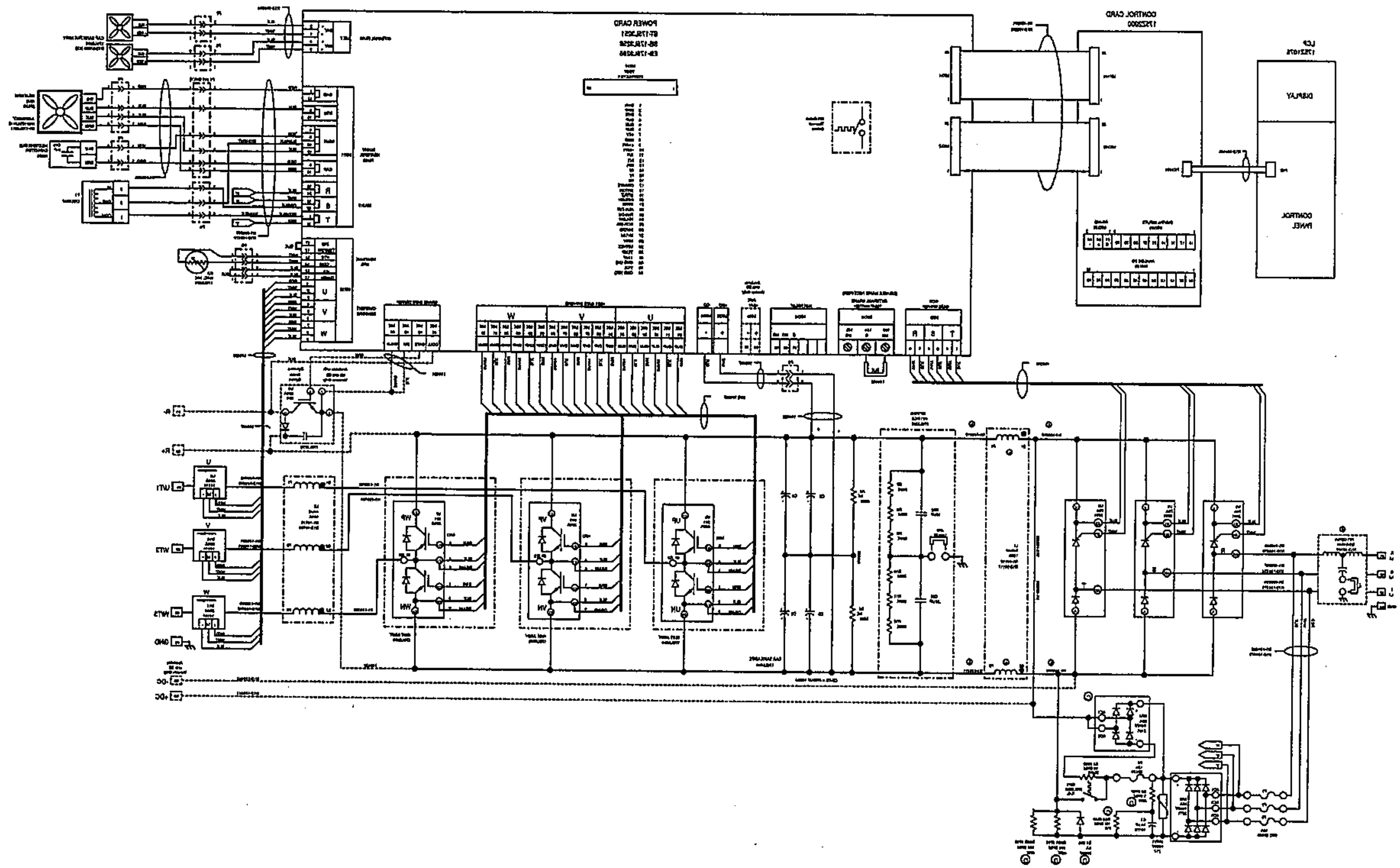
Note: For installing the wire into splicer block refer to photo below.

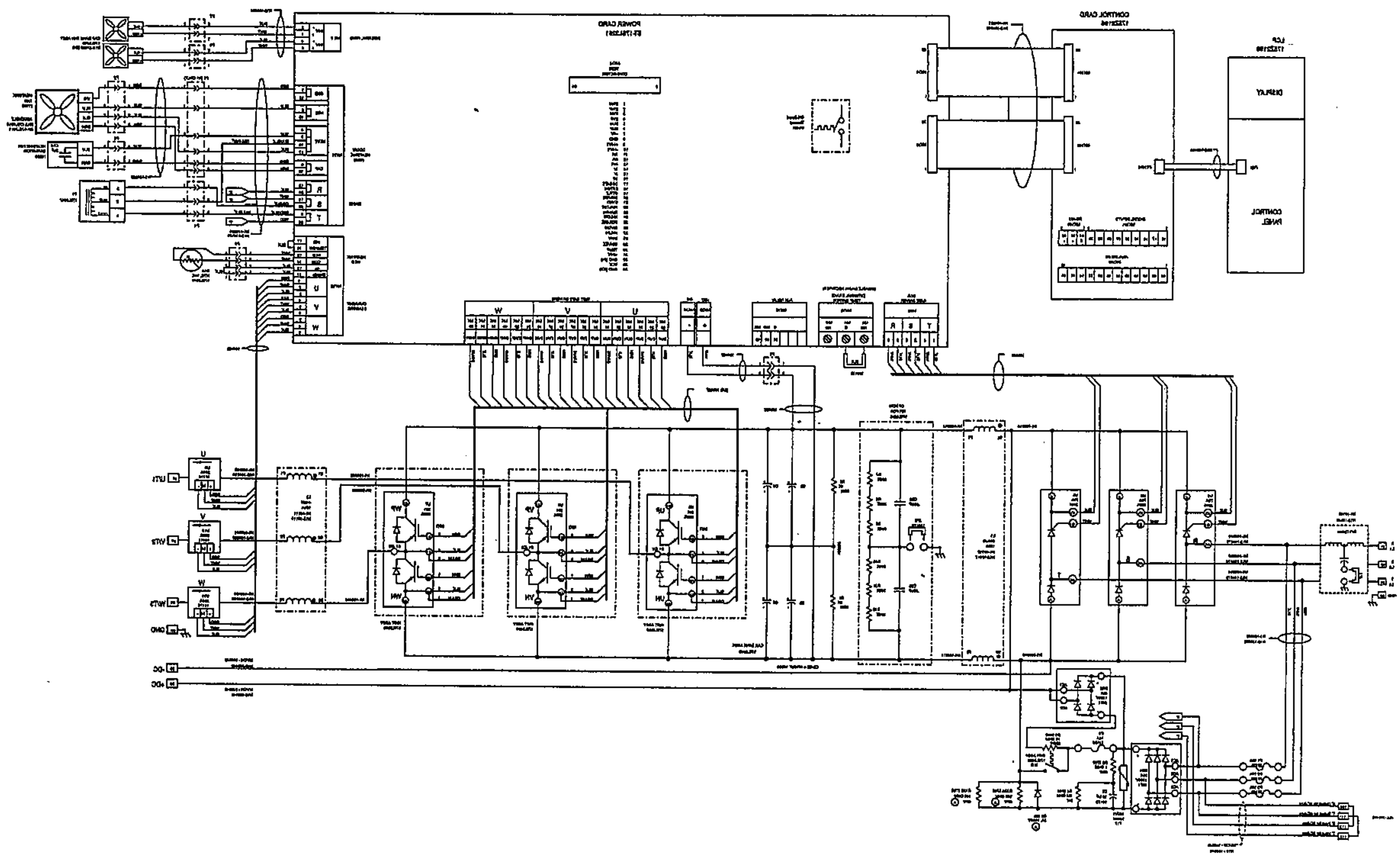
To reinstall the sensor reverse the procedure. Be sure the arrow on the top of the current sensor points towards the output of the VLT 5000.



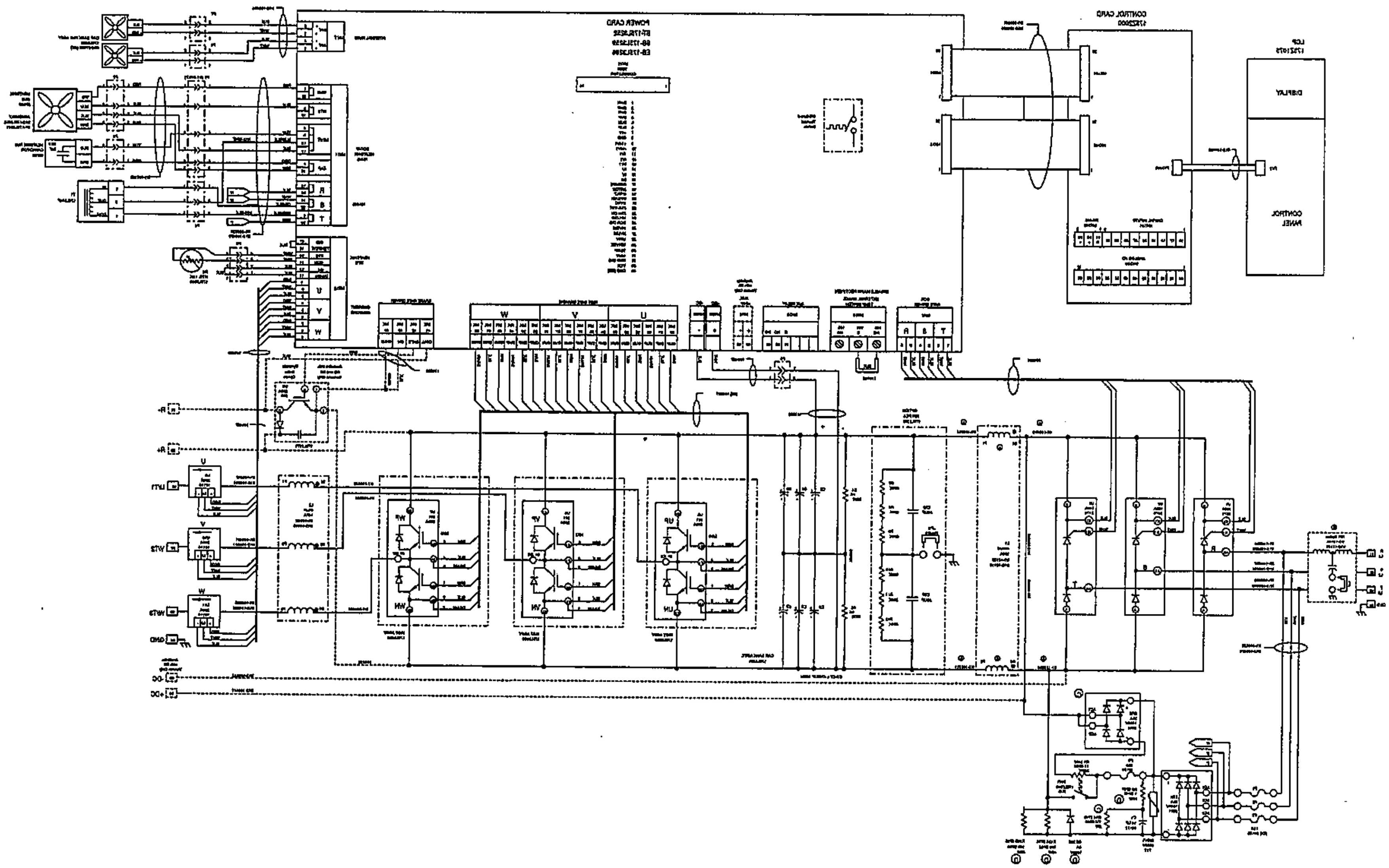
Torque the 8mm lock nuts to 16 Lb-In (2 NM)
Torque the 5/16 (8mm) hex screws to 120 Lb-In (14 NM)

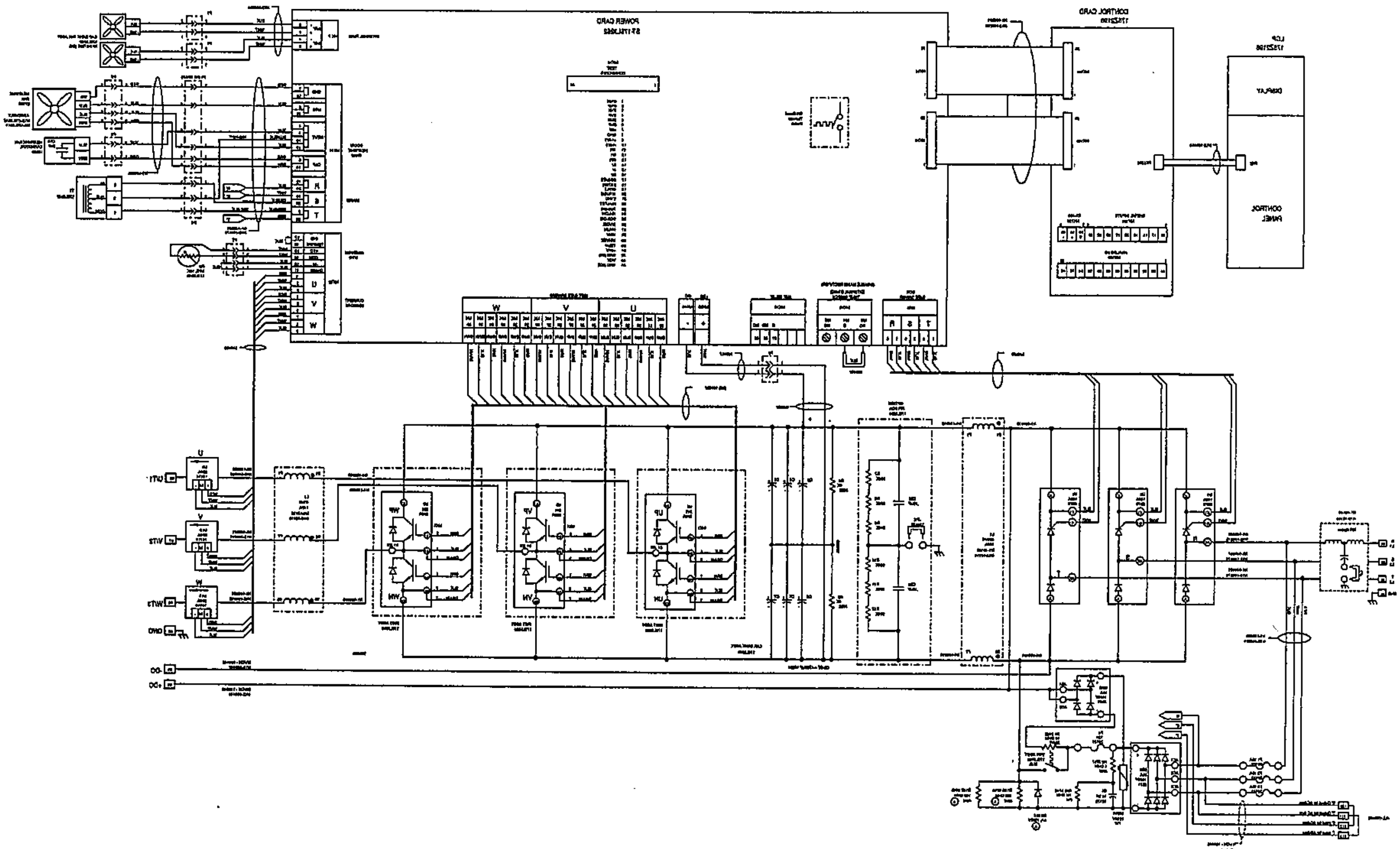
VLT 5060


POWER CARD
CONTROL CARD
LCP
DISPLAY
CONTROL PANEL
U
V
W
R
S
T
-DC
+DC
GND

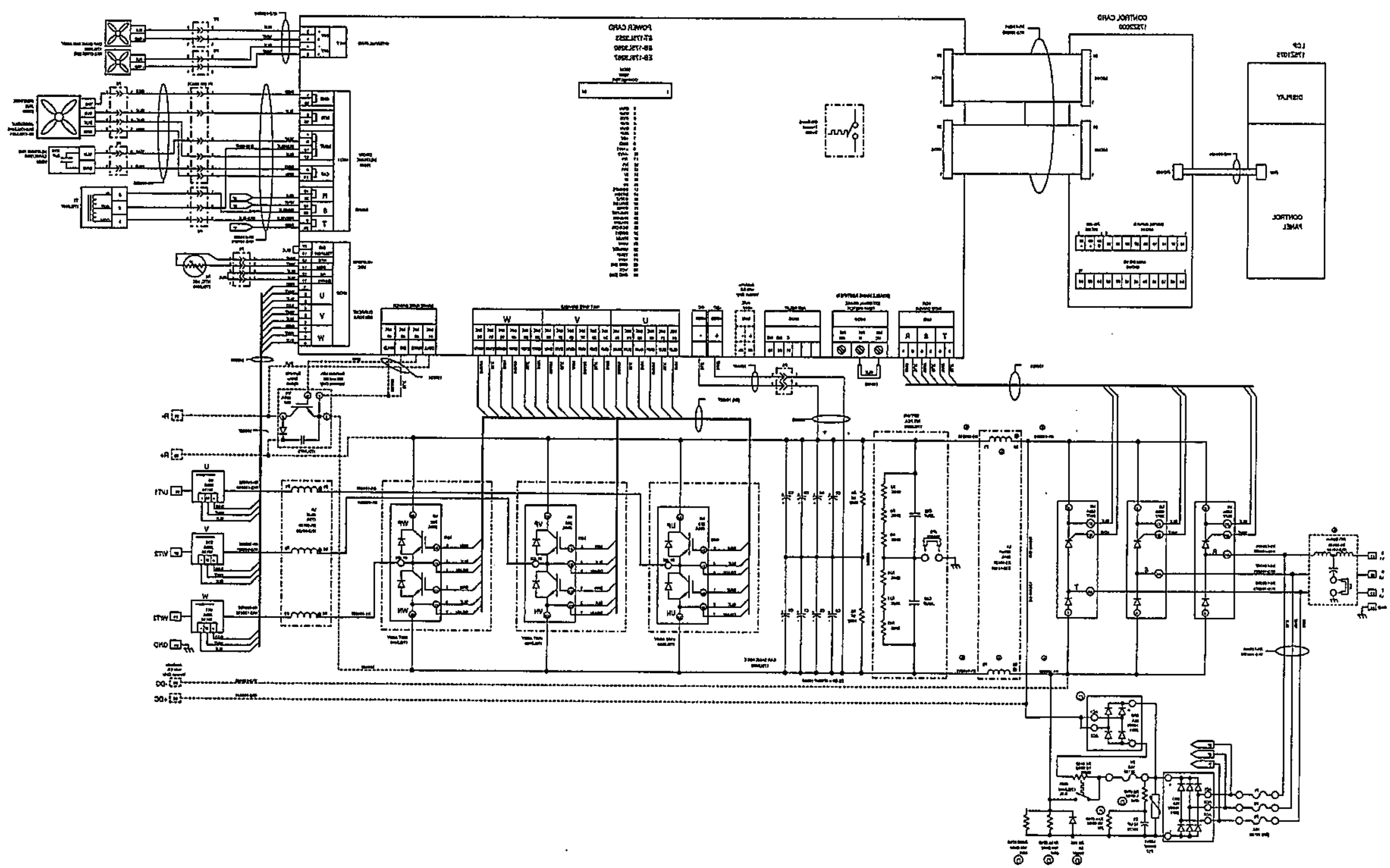

POWER CARD
CONTROL CARD
LCP
DISPLAY
CONTROL PANEL
U
V
W
R
S
T
-DC
+DC
GND

VLT 5075

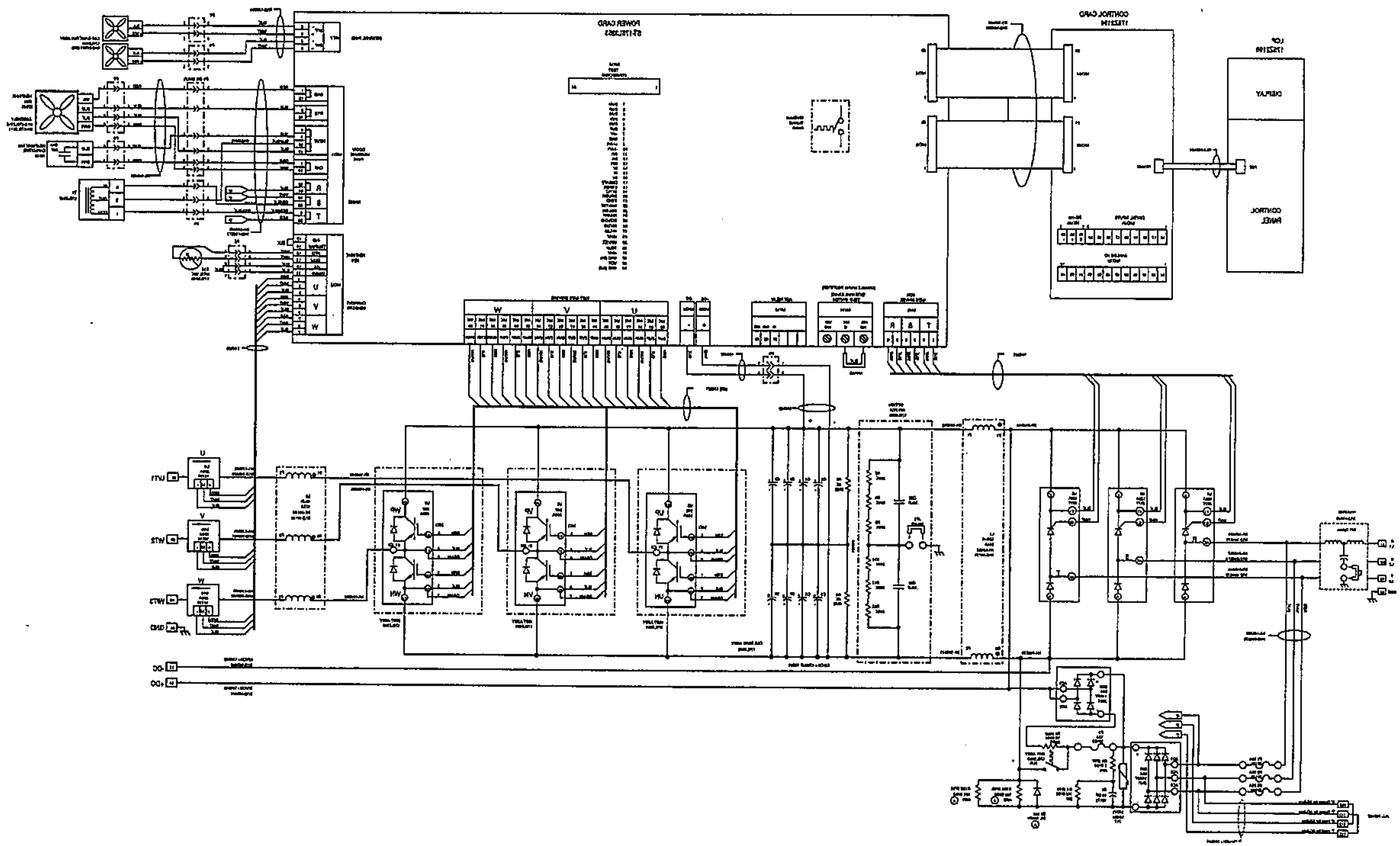


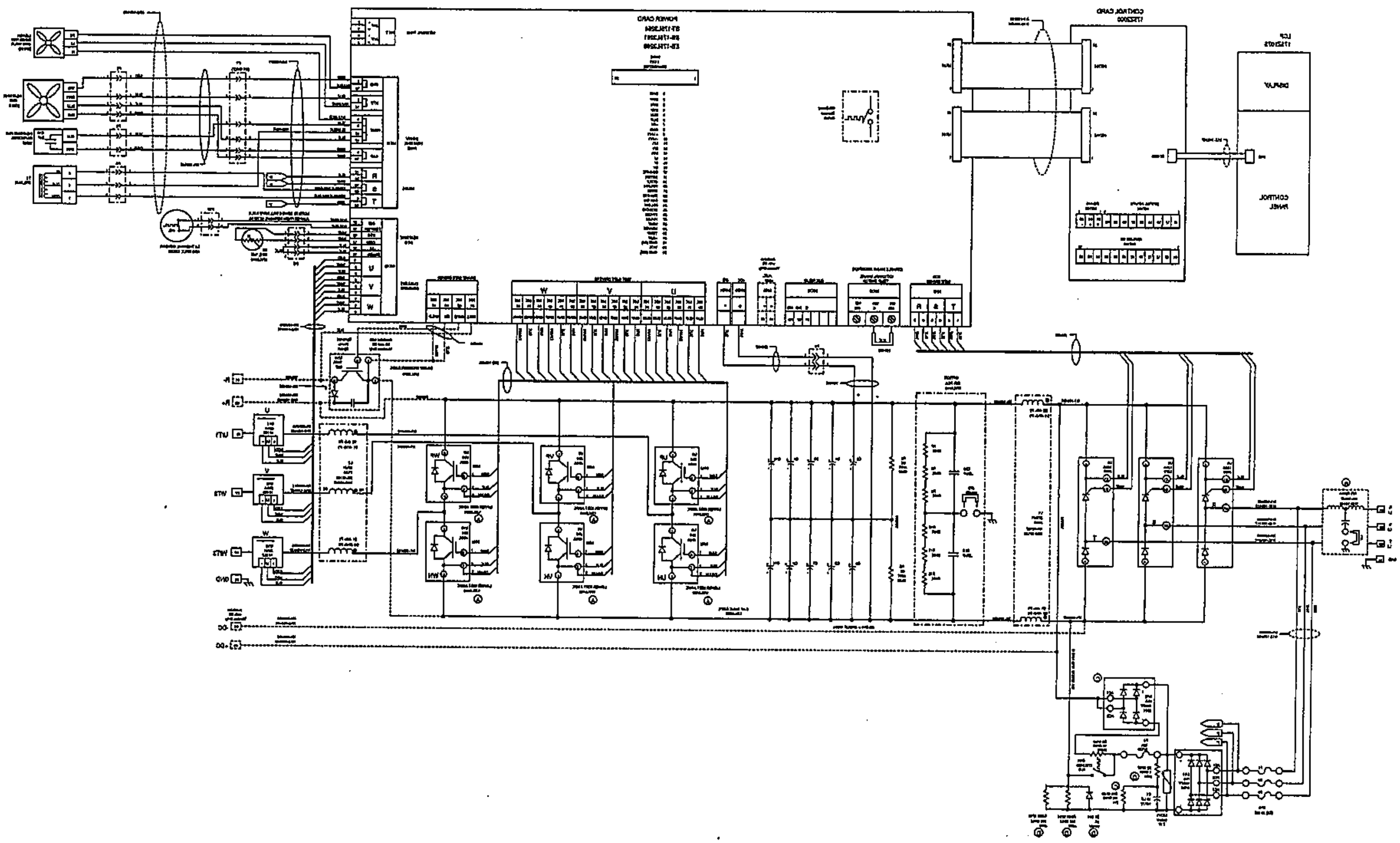


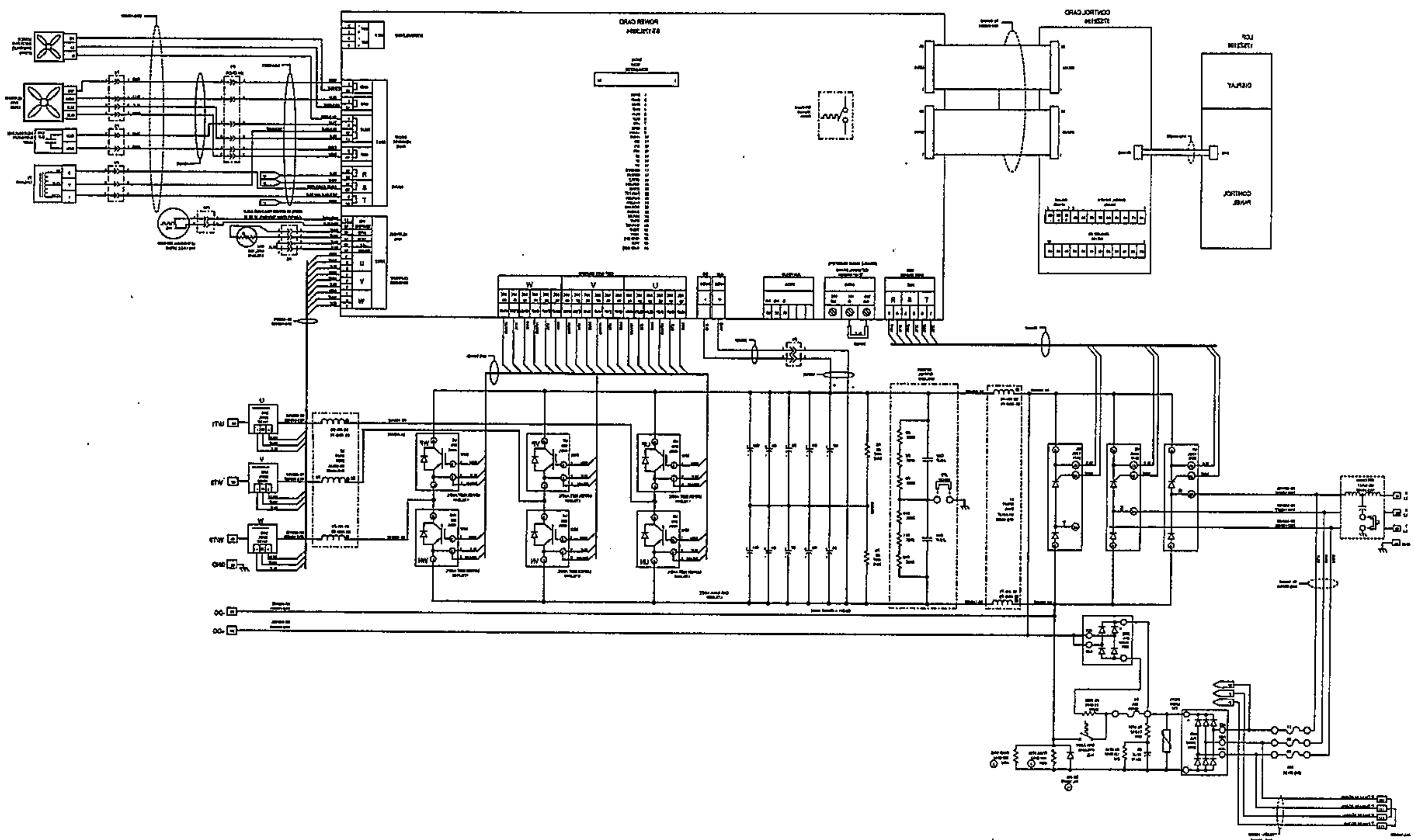
VLT 5100



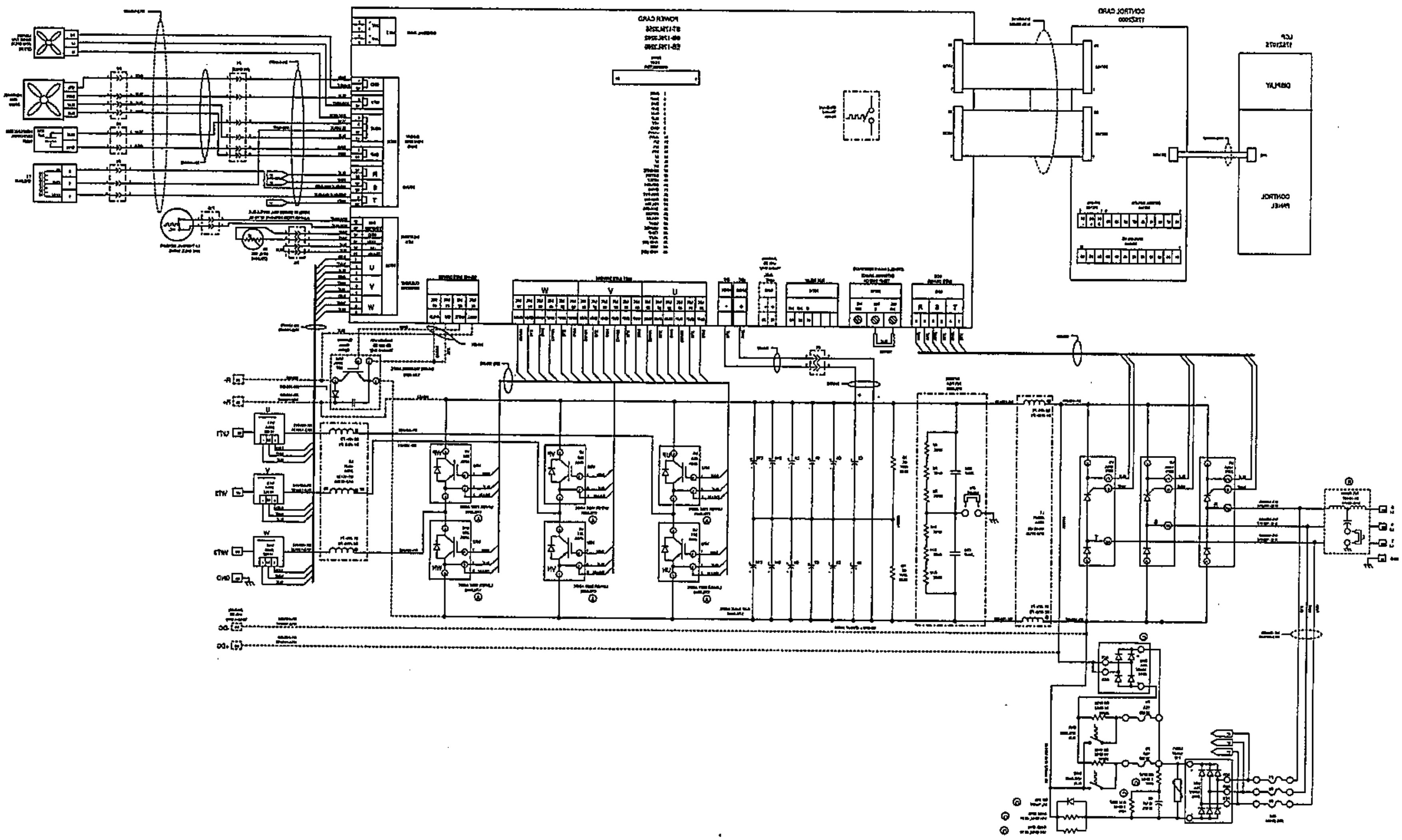
VLT 6125 and 5125 Aqua

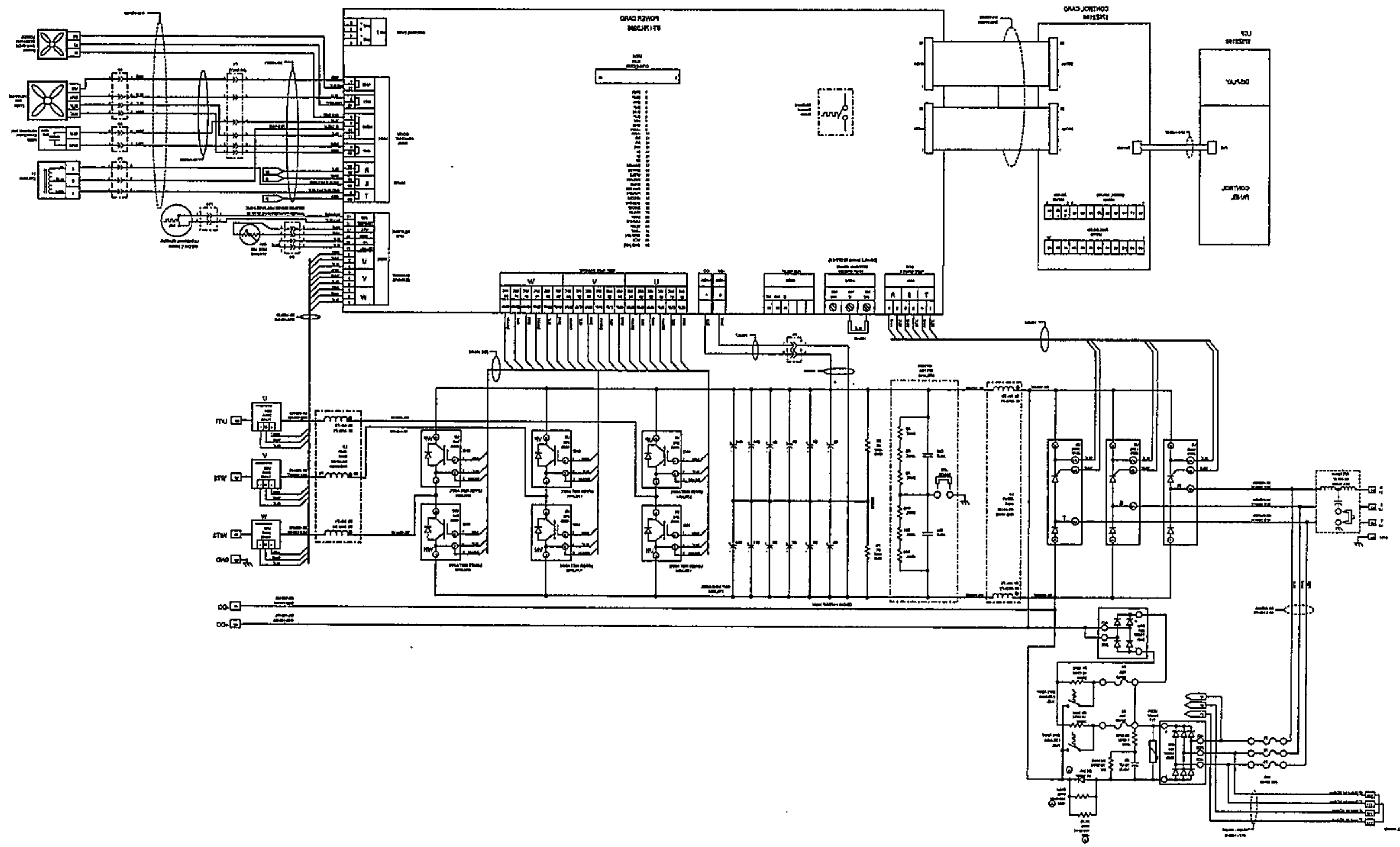


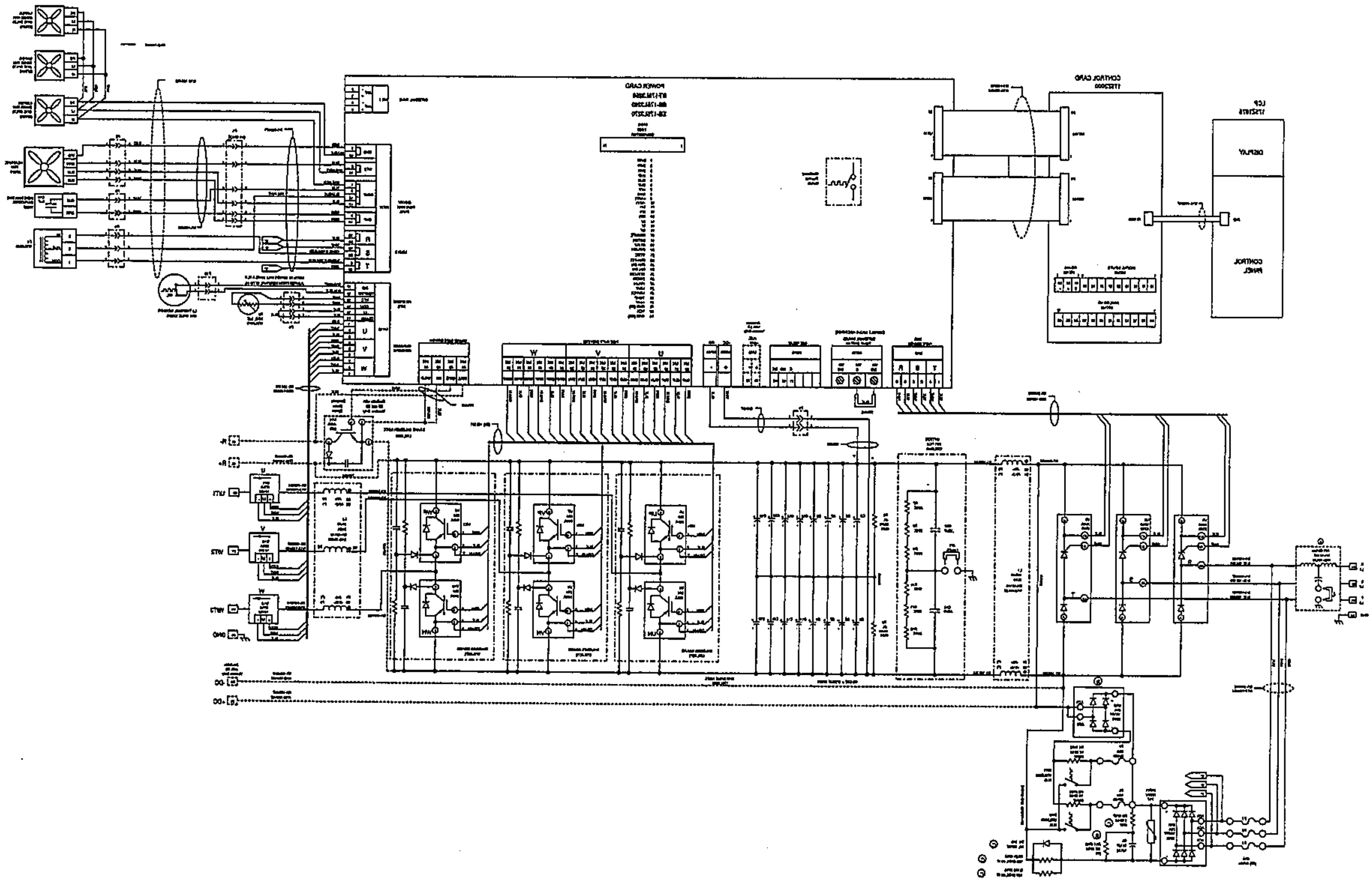

POWER CARD
CONTROL CARD
LCP
DISPLAY
CONTROL PANEL
U
V
W
R
S
T
DC-
DC+
GND


POWER CARD
CONTROL CARD
LCP
DISPLAY
CONTROL PANEL
U
V
W
R
S
T

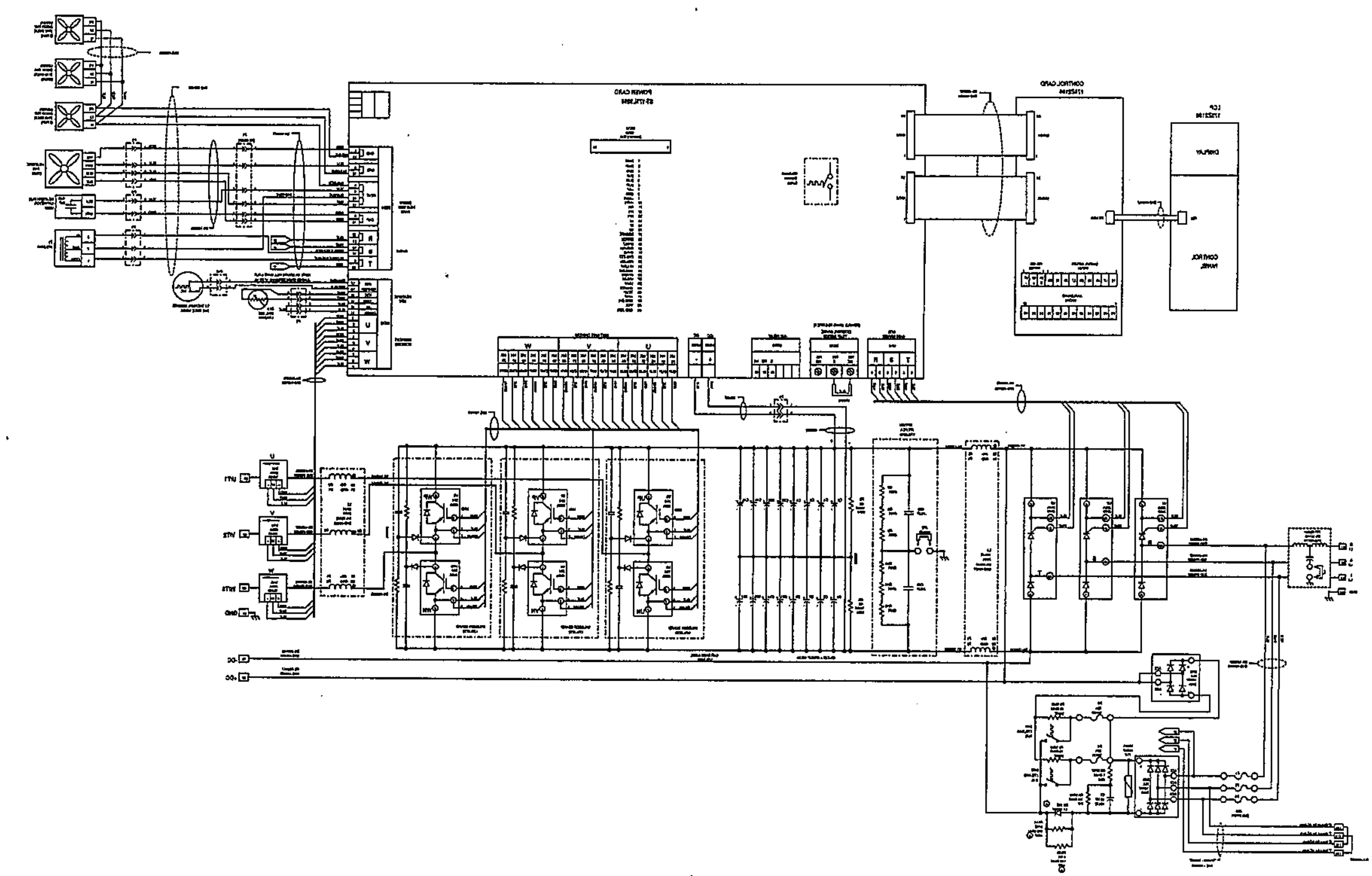
VLT 5150

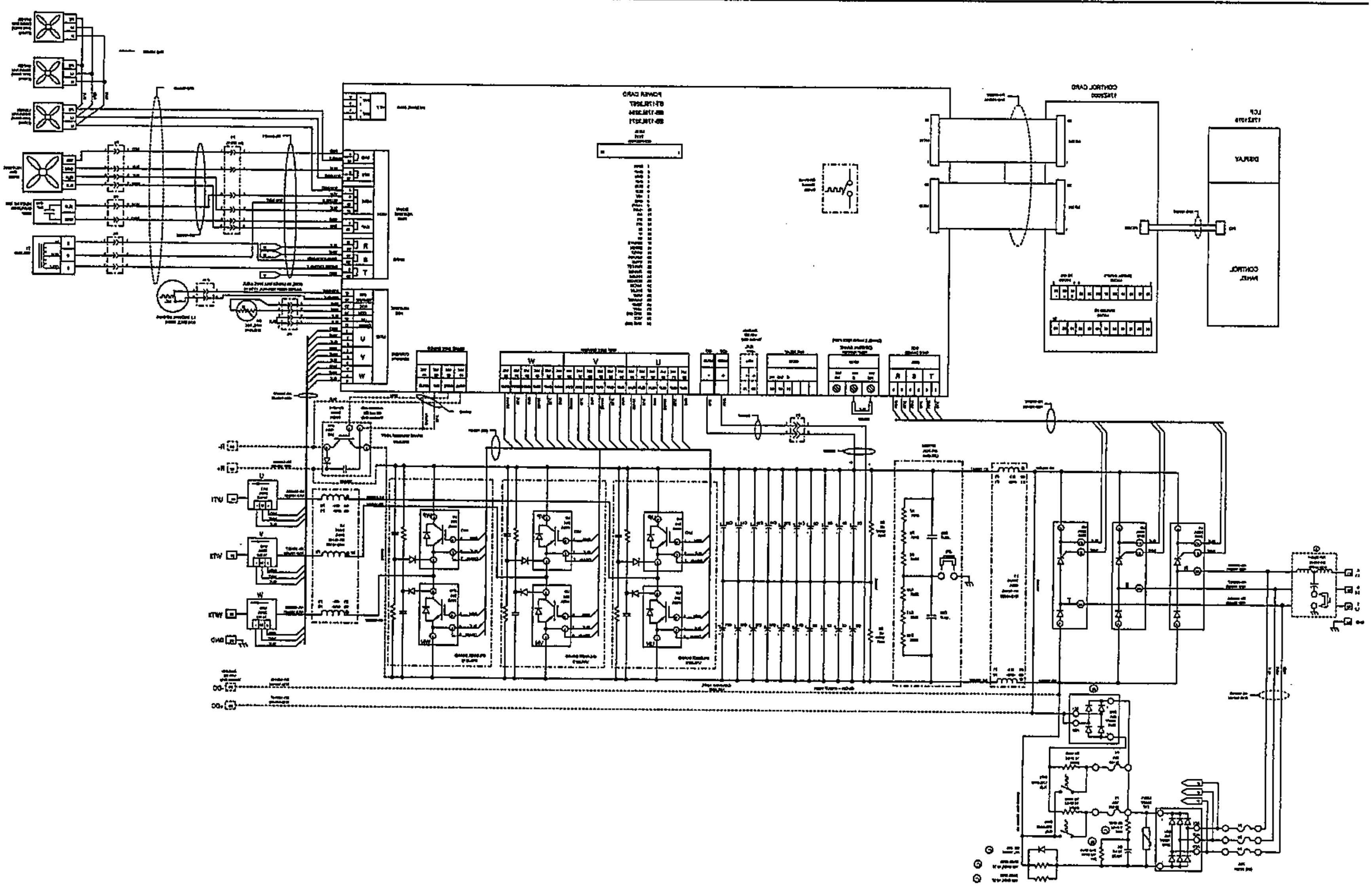




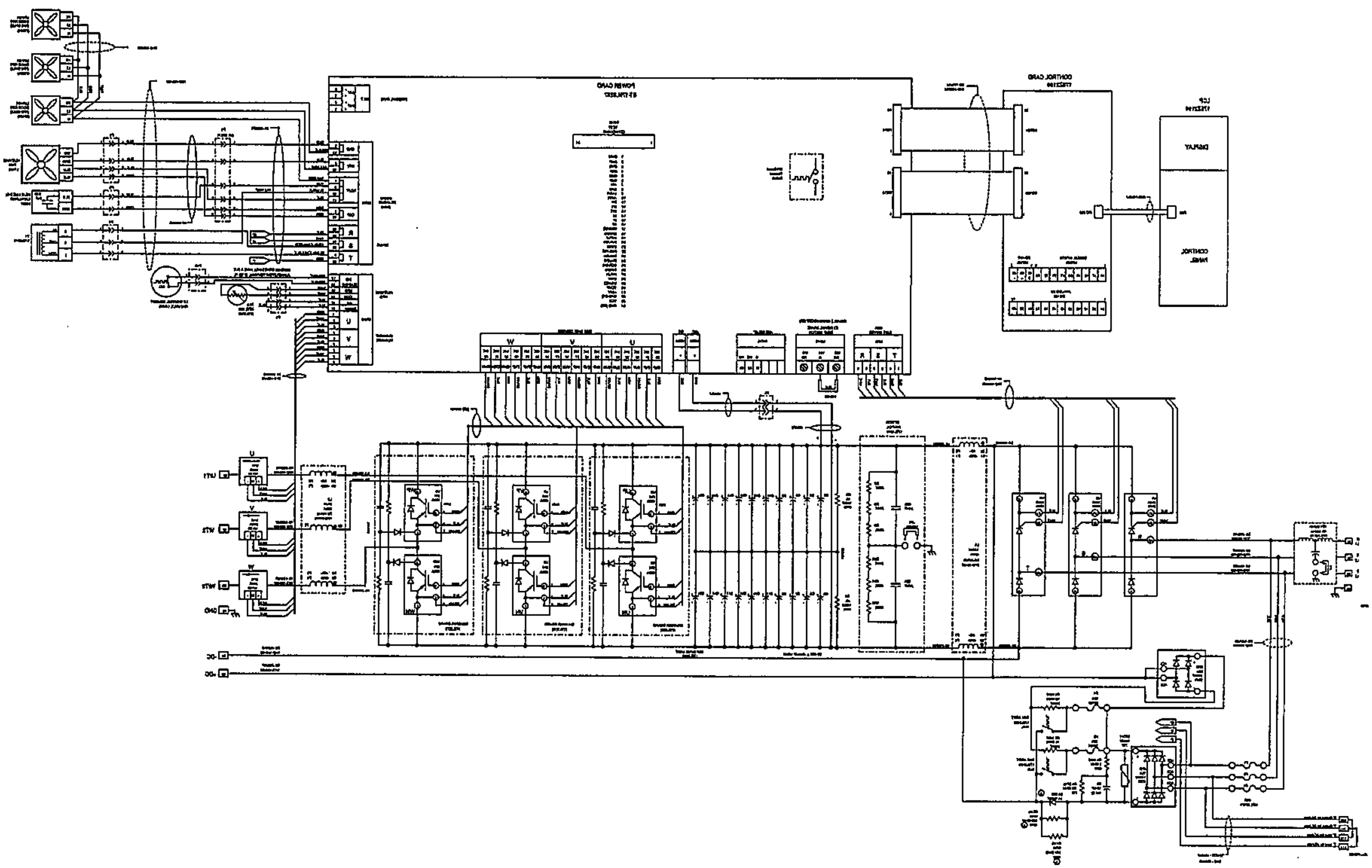

POWER CARD
CONTROL CARD
LCP
DISPLAY
CONTROL PANEL

VLT 6225 and 5250 Aqua




POWER CARD
CONTROL CARD
LCP
DISPLAY
CONTROL
PANEL
U
V
W
R
S
T

VLT 6275 and 5300 Aqua



VLT® 5060 - 5250
SCR/Diode Installation and Torque Specifications

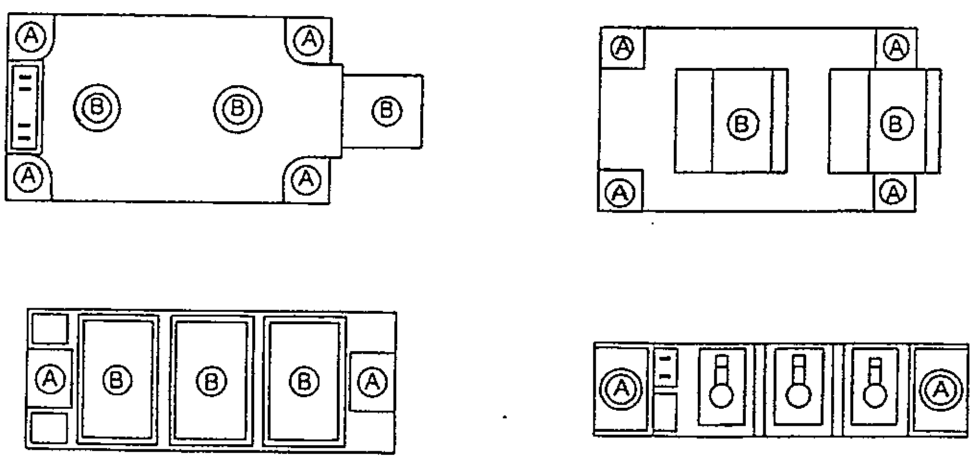
Installation

> **Note:** For the VLT 5060 - 5250, the SCR/Diode module ia a single package that contains both devices.

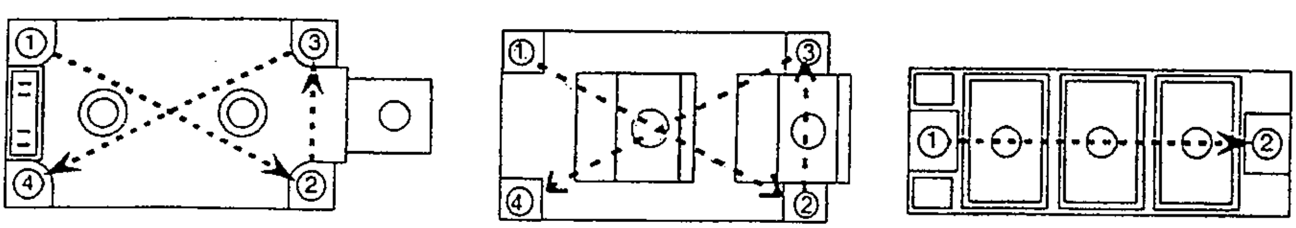
1. Prior to installing the SCR/Diode module ensure the surface area of the heatsink is clean of dirt and excess thermal compound.
2. Before installing the SCR/Diode module, place the thermal pad provided on the surface of the heatsink, aligning it with the SCR/Diode mounting holes.
3. Place the SCR/Diode module in position. Install the mounting screws and tighten by hand until the head is flush with the surface of the module.
4. Identify the SCR/Diode module style and adhere to the following tightening patterns and torque specifications as each connection to the module is made.

VLT	Torque A	Torque B
VLT 5060	44 LB•IN (5 NM)	27 LB•IN (3 NM)
VLT 5075	44 LB•IN (5 NM)	27 LB•IN (3 NM)
VLT 5100	44 LB•IN (5 NM)	44 LB•IN (5 NM)
VLT 5125	44 LB•IN (5 NM)	44 LB•IN (5 NM)
VLT 5150	44 LB•IN (5 NM)	44 LB•IN (5 NM)
VLT 5200-5250	44 LB•IN (5 NM)	80 LB•IN (9 NM)

The following figures indicate torque designation, A and B:



The following figures show tightening patterns. First, hand tighten until the screw head is flush. Second, torque to one-third of the value listed above in the pattern shown. Final torque in the same pattern to the values listed above.



VLT® 5060 - 5250
IGBT Installation and Torque Specifications

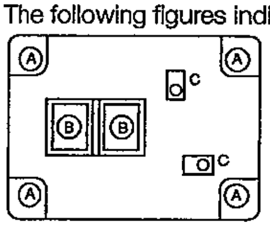
Caution: The gate of the IGBT is static sensitive. The Inverter IGBT's used in the VLT 5060-5150 have gate drive boards mounted to the gate terminals. These are not to be removed. Gate drive boards are provided with the replacement spare part IGBT.
The Inverter IGBT's used in the VLT 5200 and 5250 and all brake IGBT's will have the gate connections exposed when the snubber board is removed. Immediately after removing the snubber board a jumper must be placed across the gate leads to prevent the IGBT from being damaged by static electricity.

Installation

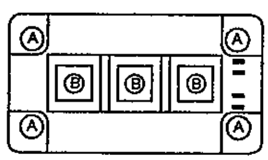
1. Prior to installing the IGBT ensure the surface area of the heatsink is clean of dirt and excess thermal compound.
2. Before installing the IGBT, place the thermal pad provided on the surface of the heatsink aligning it with the IGBT mounting holes.
3. Place the IGBT in position. Install the mounting screws and tighten by hand until the head is flush with the surface of the IGBT.
4. Identify the IGBT style and adhere to the following tightening patterns and torque specifications as each connection to the IGBT is made.

IGBT Position and VLT	Torque A	Torque B	Torque C
Inverter VLT 5060-5075	22-30 LB•IN (2.5-3.5 NM)	31-39 LB•IN (3.5-4.5 NM)	N/A
Inverter VLT 5100	22-30 LB•IN (2.5-3.5 NM)	31-39 LB•IN (3.5-4.5 NM)	N/A
Inverter VLT 5125-5150	22-30 LB•IN (2.5-3.5 NM)	31-39 LB•IN (3.5-4.5 NM)	12-15 LB•IN (1.3-1.7 NM)
Inverter VLT 5200-5250	31-39 LB•IN (3.5-4.5 NM)	66-84 IB•IN (7.5-9.5 NM)	12-15 LB•IN (1.3-1.7 NM)
Brake VLT 5060-5100	22-30 LB•IN (2.5-3.5 NM)	31-39 LB•IN (3.5-4.5 NM)	12-15 LB•IN (1.3-1.7 NM)
Brake VLT 5125-5150	22-30 LB•IN (2.5-3.5 NM)	31-39 LB•IN (3.5-4.5 NM)	12-15 LB•IN (1.3-1.7 NM)
Brake VLT 5200-5250	22-30 LB•IN (2.5-3.5 NM)	31-39 LB•IN (3.5-4.5 NM)	12-15 LB•IN (1.3-1.7 NM)

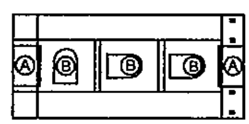
The following figures indicate torque designation, A,B or C:



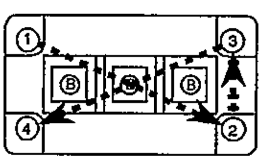
OR



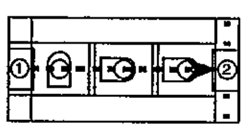
OR



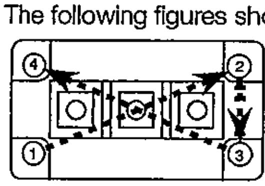
The following figures show tightening patterns. First hand tighten until the screw head is flush. Second torque to one-third of the value listed above in the pattern shown:



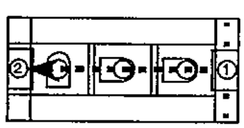
OR



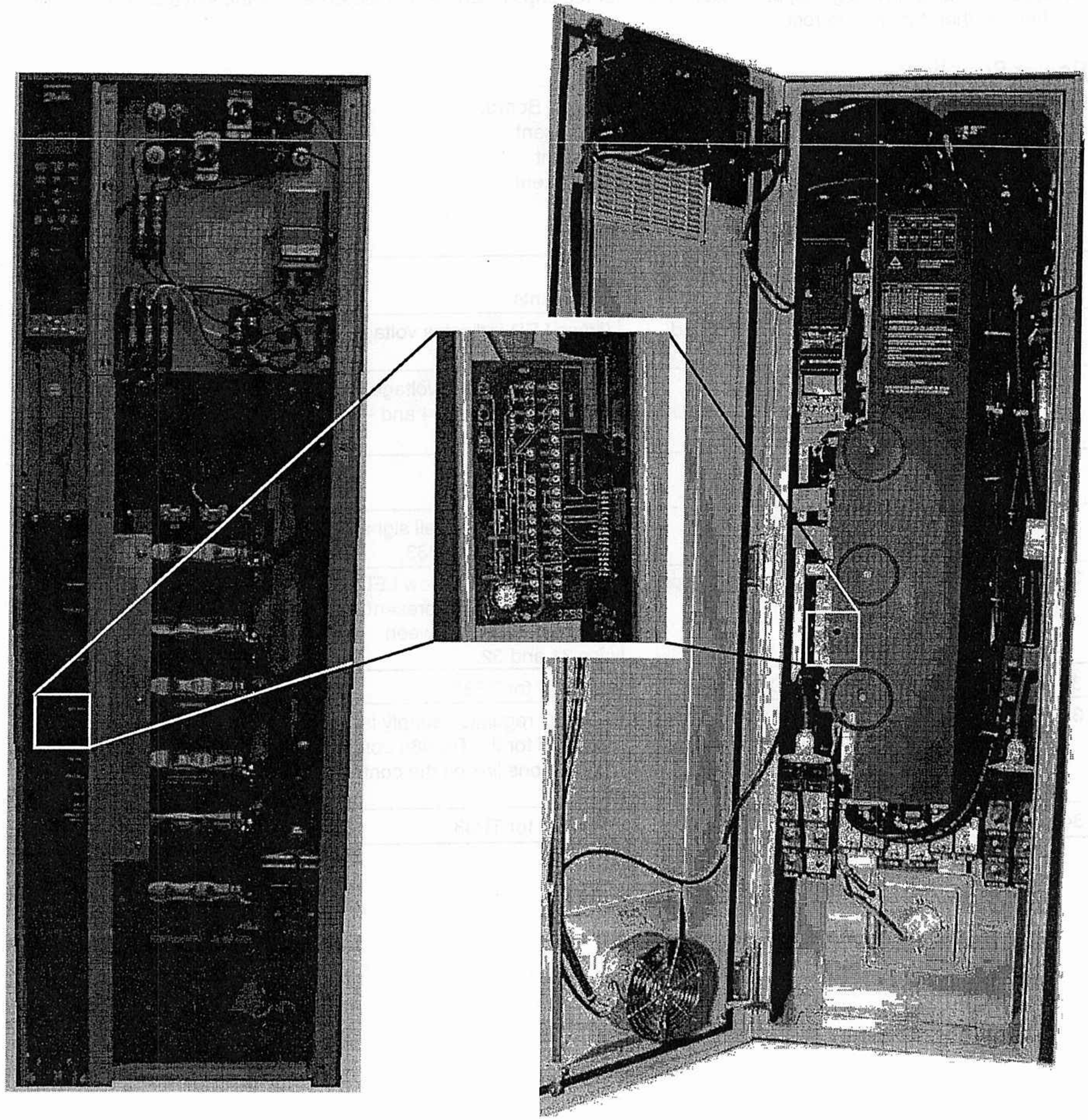
The following figures show final tightening patterns. Final torque to the value listed above in the pattern shown:



OR



The Signal Test Board can be used to monitor a variety of signals that are available from the power card. Refer to the following pages for test point and signal information. Order the Signal Test Board using part number 176F1429.



TYPICAL CHASSIS

TYPICAL NEMA 12

Signal Description and Voltage Levels:

Other than power supply measurements most of the signals being measured are made up by a waveform. Though in some cases a digital voltmeter can be used to verify the presence of such signals, it cannot be relied upon to verify the waveform is correct. An oscilloscope is the instrument of choice, however when similar signals are being measured at multiple points a digital voltmeter can be used with some degree of confidence. By comparing several signals to each other, such as gate drive signals, and obtaining similar readings it can be concluded each of the waveforms match one another and therefore are correct.

Power Supplies:

Four separate power supplies are available using the Signal Board.

+5 volt DC	Green LED indicates voltage present
±14 volt DC	Red LED indicates voltage present
+24 volt DC	Yellow LED indicates voltage present
+5 volt DC (RS485)	No LED present

Test Point No.	Color	Schematic Acronym	Function	Comments	Reading from Digital Volt Meter
7	Red	+5V	+5.0 VDC regulated supply. +4.75-5.25 VDC	Green LED indicates voltage is present.	+5.0 VDC regulated supply +4.75 to 5.25 VDC
9	Red	+14V1	+14 VDC supply. +12 VDC to +15 VDC	Red LED indicates voltage is present between +14 and −14v terminals.	+14 VDC supply. +12 to +15 VDC
10	Red	−14V1	−14 VDC supply −12 to −15 VDC	See +14v comment.	−14 VDC supply. −12 to −15 VDC
8	Black	COMMON	Logic common	This common is for all signals except TP31 and TP33.	
31	Yellow	+24V	+24 VDC power supply	+21 to +27 VDC Yellow LED indicates voltage is present +21 to +27 VDC between pins 31 and 32.	+21 to +27VDC
32	Black	COMMON	+24 VDC common	Use only for TP31	
33	White	VCX	+5.0 VDC regulated supply for RS 485. +4.75 to 5.25VDC	5.0 VDC regulated supply is reserved for the RS 485 communications link on the control card.	5 VDC between TP33 and and TP34.
34	White	GX	5v common for RS 485	Use only for TP33	

Gate Signals:

The gate signals available on the Signal Board are monitored at the low voltage side of the opto-isolator on the Power Card. The presence of the gate signal on the Signal Board does not ensure the signal is making it through the opto and to the gate of the IGBT. Reference figures 1 and 2.

Test Point No.	Test Point Color	Schematic Acronym	Function	Comments	Average Waveform Reading when using a Digital Volt Meter
1	White	BWN	IGBT gate signal, buffered, W phase, negative. Signal originates on Control Card.	Compare each Gate signal, looking for consistency between each phase.	2.3 - 2.4 VDC Equal on all phases TP1-TP6
2	White	BWP	IGBT gate signal buffered, W phase, positive. Signal originates on Control Card.	Compare each Gate signal, looking for consistency between each phase.	2.3-2.4 VDC Equal on all phases TP1-TP6
3	White	BVN	IGBT gate signal, buf fered, V phase, negative. Signal originates on Control Card.	Compare each Gate signal, looking for consistency between each phase.	2.3-2.4 VDC Equal on all phases TP1-TP6
4	White	BVP	IGBT gate signal, buffered, V phase, positive. Signal originates on Control Card.	Compare each Gate signal, looking for consistency between each phase.	2.3-2.4 VDC Equal on all phases TP1-TP6
5	White	BUN	IGBT gate signal, buffered, U phase, negative. Signal originates on Control Card.	Compare each Gate signal, looking for consistency between each phase.	2.3-2.4 VDC Equal on all phases TP1-TP6
6	White	BUP	IGBT gate signal, buffered, U phase, positive. Signal originates on Control Card.	Compare each Gate signal, looking for consistency between each phase.	2.3-2.4 VDC Equal on all phases TP1-TP6
8	Black	COMMON	Logic common	This common is for all signals except TP31, TP33 & TP34.	

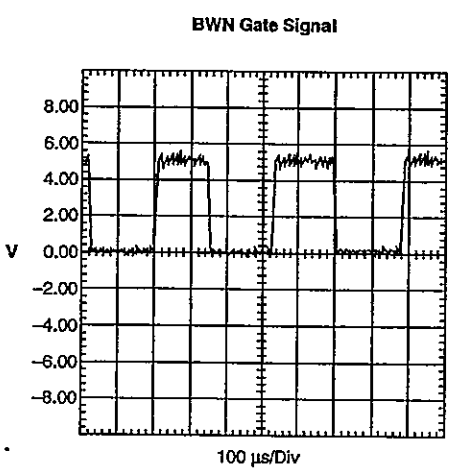


Figure 1.

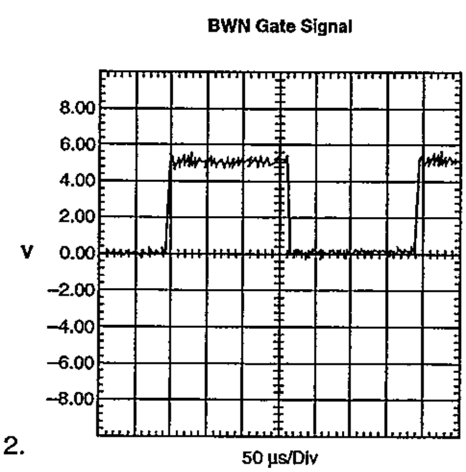


Figure 2.

Typical gate drive signal when using an oscilloscope. VLT 5000 in run mode, running at zero speed.

Current Feedback Signals

Current feedback signals consist of both non-conditioned and conditioned signals. Non-conditioned (IU1, IV1, IW1) are the non-buffered signals that come straight from the current sensor to the power card. Conditioned (IU, IV, IW) are the buffered non-conditioned signals that are sent from the Power Card to the Control Card. Reference figures 3 and 4.

Test Point No.	Test Point Color	Schematic Acronym	Function	Comments	Reading from Digital Volt Meter
11	White	IU1	Current sensed, U phase, not conditioned.	All current feedback signals should be compared to each other. All measurements will be within mV's from each other in normal operation.	Less than 15mV at zero current 890mV AC (VLT 5100 at 87A)
12	White	IV1	Current sensed, V phase, not conditioned.	All current feedback signals should be compared to each other. All measurements will be within mV's from each other in normal operation.	Less than 15mV at zero current 890mV AC (VLT 5100 at 87A)
13	White	IW1	Current sensed, W phase, not conditioned.	All current feedback signals should be compared to each other. All measurements will be within mV's from each other in normal operation.	Less than 15mV at zero current 890mV AC (VLT 5100 at 87A)
14	White	IU	Current sensed, U phase, conditioned.	All current feedback signals should be compared to each other. All measurements will be within mV's from each other in normal operation.	Less than 15mV at zero current 890mV AC (VLT 5100 at 87A)
15	White	IV	Current sensed, V phase, conditioned.	All current feedback signals should be compared to each other. All measurements will be within mV's from each other in normal operation.	Less than 15mV at zero current 890mV AC (VLT 5100 at 87A)
16	White	IW	Current sensed, W phase, conditioned.	All current feedback signals should be compared to each other. All measurements will be within mV's from each other in normal operation.	Less than 15mV at zero current 890mV AC (VLT 5100 at 87A)
8	Black	COMMON	Logic common	This common is for all signals except TP31 and TP33.	

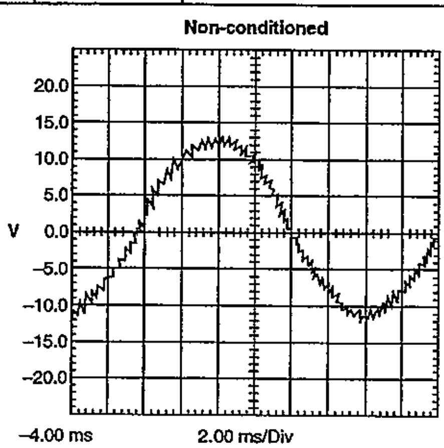


Figure 3.

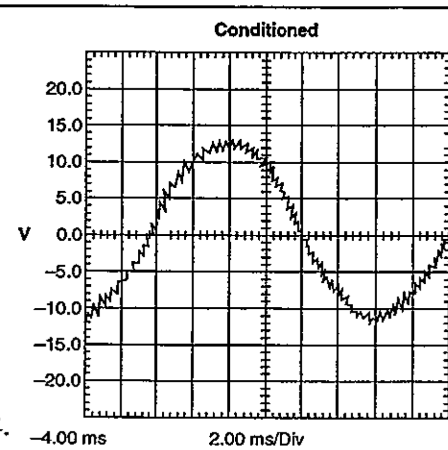


Figure 4.

Typical current feedback waveform when using an oscilloscope. VLT 5100 at 84 amps.

Brake Signals

The DBGATE signal is enabled by signal (BRPWM) originating from the Control Card. The DBGATE signal is monitored at the low voltage side of the opto-isolator on the Power Card. The presence of the gate signal on the Signal Board does not ensure the signal is making it through the opto and to the gate of the IGBT. The DBRTON signal is the low voltage feedback indicating the brake IGBT is conducting by a flow of current through the collector to the emitter. Reference figures 5 and 6.

Test

1) Insure drive is running at zero speed.
2) For SB and EB drives only, change parameter 400 to Resistor.
   A resistor must be hooked up to the drives R+ and R– terminals.
3) Display DC Link Voltage in the LCP. (Parameter 009-012 can be changed to customize display).
4) Close Over Volt Test switch (down position).
5) Monitoring voltage in display, increase the DC Link Voltage by turning the potentiometer counter clockwise.
   a) check brake operation message in LCP and verify signal (DBGATE DBRTON)
      ~795vDC Brake turn on voltage (380-500 volt units)
      ~390vDC Brake turn on voltage (200-240 volt units)
6) Upon completion of the tests turn potentiometer fully clockwise and open switch (up position).
7) Return all changed parameters to original settings.

Test Point No.	Test Point Color	Schematic Acronym	Function	Comments	Reading from Digital Volt Meter
17	White	DBGATE	Brake IGBT gate pulse train.	Pulse wave form. May use OVERVOLTAGE TEST switch and potentiometer to force braking.	4.04 volt DC level with brake turned off. Voltage drops to zero when brake is turned on.
18	White	DBRTON	Brake IGBT 5V logic level signal.	Pulse wave form. May use OVERVOLTAGE TEST switch and potentiometer to force braking.	5.10 volt DC level with brake turned off. Voltage drops to zero when brake is turned on.
8	Black	COMMON	Logic common	This common is for all signals except TP31 and TP33.	

DBGATE

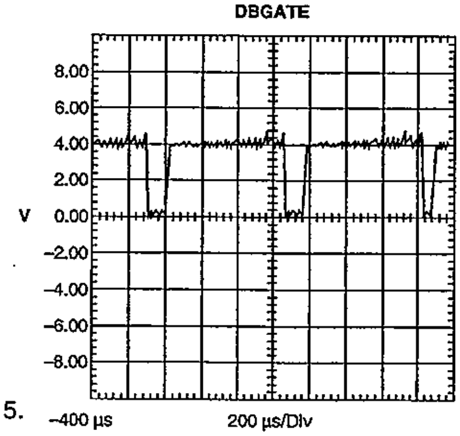


Figure 5.

DBRTON

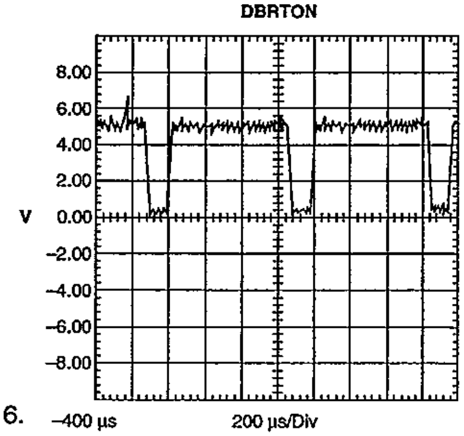


Figure 6.

Typical waveform when using an oscilloscope. VLT 5060 at zero speed using the Overvolt Test switch to force braking.

Fan Signals

FAN-ON - Is active anytime the fan is running, either high or low speed. The waveforms falling edge is synchronized with AC line (S & T). If the fan is off, this signal is pulled to –14 volt DC.

45°C the fan is turned on low speed
60°C the fan is turned on high speed
55°C the fan is turned from high to low speed
<30°C the fan is turned off

HI-LOW - This signal changes the fans speed to high speed.
Reference figures 7 and 8.

Test

1) Power must be applied to drive, but RUN command is not necessary.
2) Display Heatsink Temp in LCP. (Parameter 009-012 can be changed to customize display).
3) Monitor FAN-ON and/or Monitor HI-LOW
4) Close Fan Test switch (down position).
   a) Verify FAN-ON signal (high speed only)
   b) Verify HI-LOW voltage
5) Open Fan Test switch (up position), view heatsink temperature in LCP if <55°C verify if fan is running in low speed by the FAN-ON signal. If fan is off start and run drive if possible, to heat up the heatsink. Once the heatsink temperature is >45°C fan will be on low speed, verify FAN-ON signal.
6) Upon completion of tests insure Fan Test switch is open (up position).

Test Point No.	Test Point Color	Schematic Acronym	Function	Comments	Reading from Digital Volt Meter
23	White	FAN-ON	Fan speed control TRIAC gate pulse train.	Rectangular pulses is turned off by FANO signal (heat sink temperature < 45°C) from control card at which time FAN-ON is forced to –14v.	
24	White	HI-LOW	Commands the fan speed control circuit to run the fans fast .	Commands the fan speed control circuit to run the fans fast when the hear sink is over 60°C or other conditions warrant or when the POWER CARD TESTER FAN TEST switch is closed. Fast ~230VAC, slow ~165VAC at the fan terminals.	0 vDC with fan off. 14 vDC with fan on high.
8	Black	COMMON	Logic common	This common is for all signals except TP31 and TP33.	

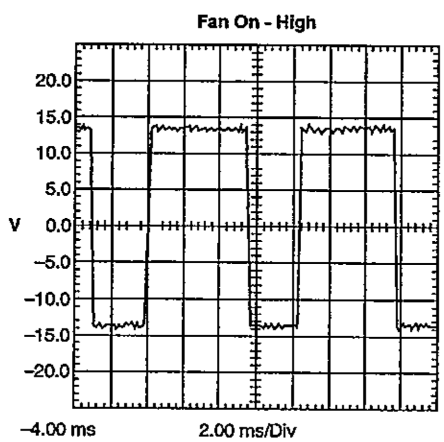


Figure 7.

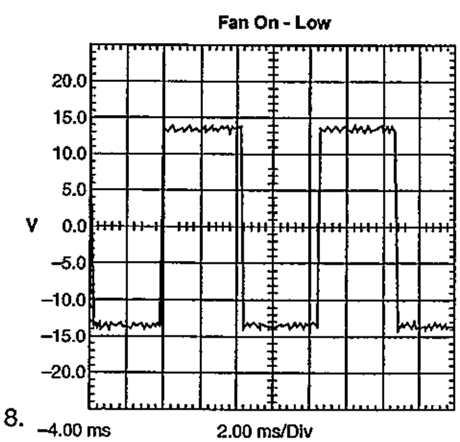


Figure 8.

Typical waveform when using an oscilloscope. Fan On - High was forced by using the Fan Test Switch. Fan On - Low was with the drive running at 60Hz and the heatsink above 45°C.

DC Bus Signals

Use the following signal to verify actual DC Bus voltage (UINV) or determine if the upper limit of the DC bus has been reached (HVLIM).

UNIV - A scaled low voltage representation of the DC bus voltage.
Use the formula [256 • (meter voltage) = DC Bus voltage] to determine if the power card is relaying the correct information to the processor.

HVLIM - This signal is high when an upper limit is reached.

HVLIM set points in the drive.
380-500 volt units 815 volts DC
200-240 volt units 400 volts DC

Test

1) Insure drive is running at zero speed.
2) Display DC Link Voltage in the LCP. (Parameter 009-012 can be changed to customize display).
3) Disconnect brake resistors R+ and R– if applicable, turn Parameter 400 off (SB and EB units only).
4) Close Over Volt Test switch (down position).
5) Monitor voltage in display, increase the DC Link Voltage by turning the potentiometer counter clockwise.
   a) Record Warning and Alarm voltage set points, verify signal voltage once high voltage limit is reached (HVLIM)
      Warnings: 200-240 volt units 384 w/o brake — 405 w/brake ±5%
      380-500 volt units 801 w/o brake — 840 w/brake ±5%
      Alarms: 200-240 volt units 425 volts DC ±5%
      380-500 volt units 855 volts DC±5%
   b) Verify DC Link voltage (UNIV)
      [256 • (meter voltage) = DC Bus voltage]
6) Upon completion of tests turn potentiometer fully clockwise and open switch (up position).
7) Return all changed parameters to original settings.

Test Point No.	Color	Schematic Acronym	Function	Comments	Reading from Digital Volt Meter
27	White	HVLIM	High bus voltage limit has been exceeded. ~+6v indicates over threshold, ~–6v indicates under.	Nominal bus voltage threshold is ~815v (790-840v).	–6 VDC no high voltage fault 6 VDC with active high voltage fault
28	White	UINV	Bus voltage scaled down to 1/256 ±3%	@ 500v bus, 1.953v, (1.924v to 1.98v) @ 800v bus, 3.125v, (3.078v to 3.172v)	Formula for determining DC bus voltage [256 • (meter voltage) = DC bus level]
8	Black	COMMON	Logic common	This common is for all signals except TP31 and TP33.	

Auxiliary Signals

OTFLT - PCB-OT (Power Card Over Temp Signal), PCB-UT (Power Card Under Temp Signal), IND-OT (Inductor Over Temp Signal), and EXTDIS (MK10 jumper terminals 106 & 104) are inputs to a four input Nor Gate that gives an Over Temperature fault on the Power Card. The OTFLT is also sent to disable the input SCR's.

INRUSH - This signal is sent from the Control Card to a 4 input NOR gate that is then sent to the low voltage side of the opto-isolator for the SCR's gate. It is also used for gating the internal 24 volt fans. Reference figure 9.

SYNC - This is the carrier frequency signal. This could be used as an external trigger function for an Oscilloscope. Reference figures 10 and 11.

SCR-DIS - This signal is on the low voltage side of the input SCR's and internal fan Gate signals, which forces the signal low turning the input SCR's off.

TEMP - This signal is the analog voltage from the NTC. It can be used to determine correct feedback from heatsink thermal sensor through the acquired voltage on test point 30, using this formula [$2.82 - (\Delta T \bullet .035) = V_{TEMP}$] ΔT = heatsink temperature −30°C

Test

1) Power must be applied to the drive, but a RUN command is not necessary.
2) Display Heatsink Temp in LCP. (Parameter 009-012 can be changed to customize display).
   a) Measure and verify TEMP with displayed temperature.
      [$2.82 - (\Delta T \bullet .035) = V_{TEMP}$] ΔT = heatsink temperature −30°C
3) Close Fan Test switch, view heatsink temperature in LCP and compare temperature with voltage from signal using the formula above.
4) Upon completion of tests insure Fan Test switch is open (up position).

Test Point No.	Color	Schematic Acronym	Function	Comments	Reading from Digital Volt Meter
19	White	OTFLT	Combined inductor (LED3), brake resistor (LED4), and power card over temperature (LED1) faults plus power card under temperature (LED2) fault. (LED1) faults plus power under temperature (LED2) fault. OTFLT will turn off front end SCRs and inverter IGBTs.	Verify jumper is present in terminal block of MK10 of the Power Card. Terminals 106 to 104.	Fault = 0v, no fault = 5v
20	White	INRUSH	Signal from BCC enabling turning on the front end SCRs.		Use oscilloscope
21	White	SYNC	The carrier frequency of the drive.	This is the carrier frequency signal. This could be used as an external trigger function for an oscilloscope.	
25	White	SCR-DIS	0v indicates SCRs and internal fans (24vdc) disabled. Enabled signal level is 0.6 to 0.8 volts.	SCRs and internal fans are turned on by INRUSH signal from the control card	
30	White	TEMP	Provides a low voltage analog signal proportional to heat sink temperature.	Will read ~3.267 volts if the circuit to the NTC on the heat sink is open. As heatsink temperature increases the TEMP signal decreases.	Formula for determining heatsink temp [$2.82 - (\Delta T \bullet .035) = V_{TEMP}$] ($\Delta T$ = heatsink Temp. −30°C)
8	Black	COMMON	Logic common	This common is for all signals except TP31 and TP33.	

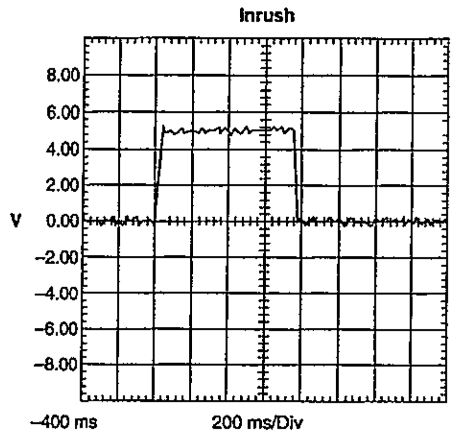


Figure 9

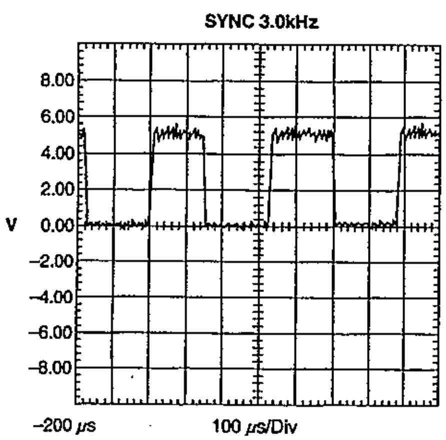


Figure 10

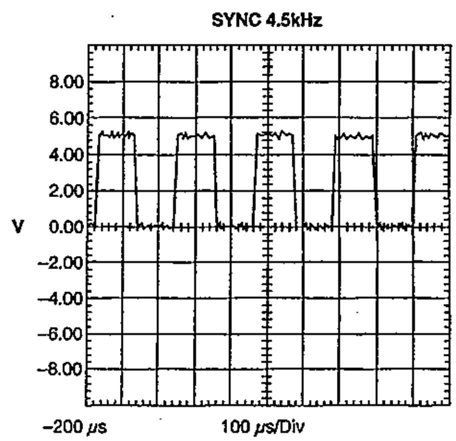


Figure 11

Switches / Potentiometer

Three switches on the Signal Board are used in conjunction with select signals to either force conditions or verify signals are operational.

Fan Test - This switch will force the fan on high speed. This enables you to check the FAN-ON, HI-LOW signals. Also use the TEMP signal to verify the change in heatsink temperature.

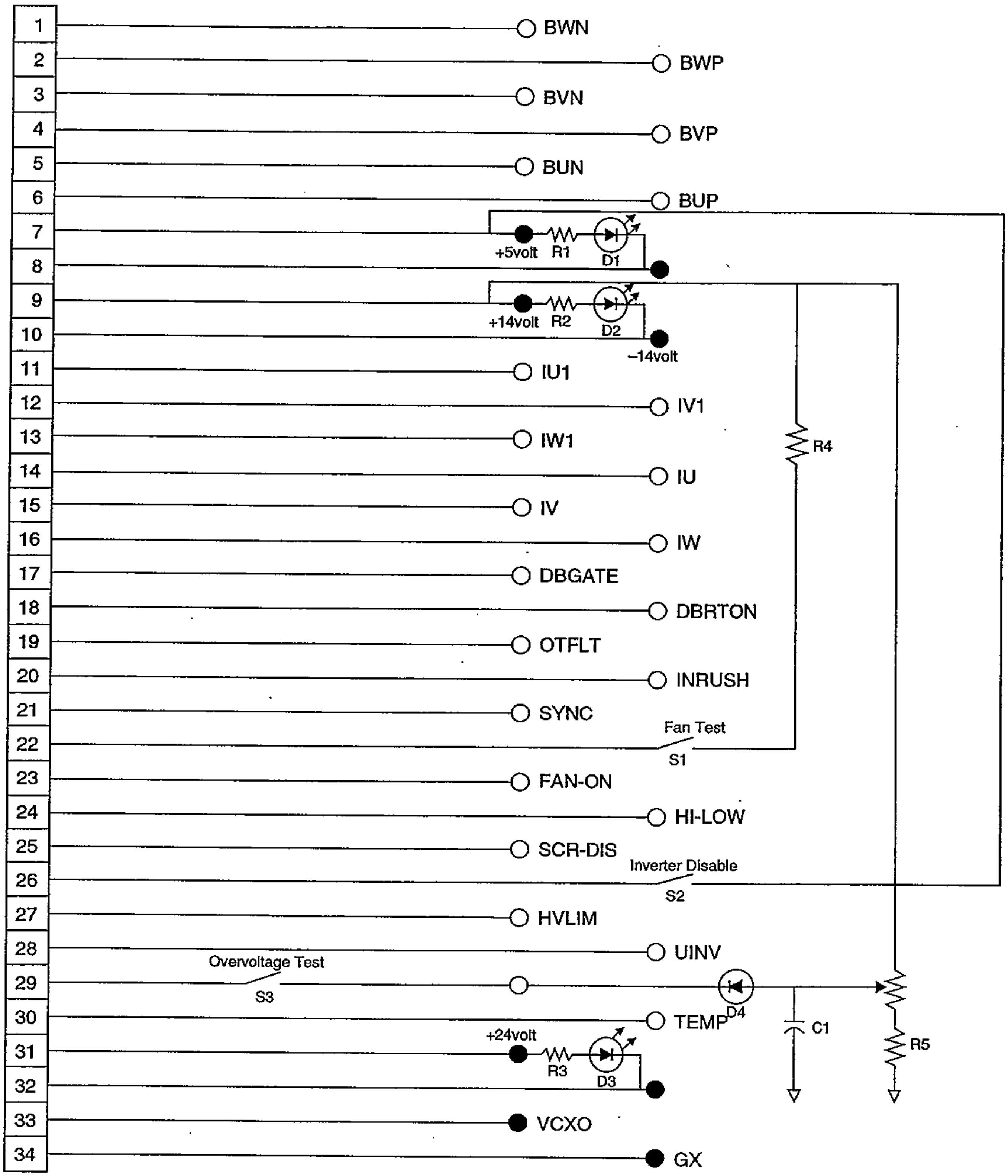
1) Power must be applied to the drive, but a RUN command is not necessary.
2) Display Heatsink Temp in LCP. (Parameter 009-012 may be changed to customize display).
3) Monitor FAN-ON and/or Monitor HI-LOW
4) Close Fan Test switch (down position).
   a) Verify FAN-ON signal (high speed only)
   b) Verify HI-LOW voltage
   c) Measure and verify TEMP signal is changing with displayed temperature.
   $[2.82 - (\Delta T \bullet .035) = V_{TEMP}]$ ΔT = heatsink temperature –30°C
5) Open the Fan Test switch (up position), view heatsink temperature in LCP if ≤55°C verify if fan is running in low speed by the FAN-ON signal. If fan is off, start and run drive if possible, to heat up the heatsink. Once the heatsink temperature is >45°C fan will be on low speed, verify FAN-ON signal.
6) Upon completion of tests insure Fan Test switch is open (up position).

Inverter Dis - This switch will cause the drives output section to be disabled. This is only functional in Rev E power cards.

OverVolt Test - This switch can be used to check the DBGATE, DBRTON, HVLIM< and UINV are in working order.

1) Insure the drive is running at zero speed.
2) Display DC Link Voltage in the LCP. (Parameter 009-012 may be changed to customize display).
3) Disconnect brake resistors R+ and R– if applicable, turn Parameter 400 off (SB and EB units only).
4) Close the Over Voltage Test switch (down position).
5) Monitoring voltage in display, increase the DC Link Voltage by turning the potentiometer counter clockwise.
   a) Record warning and Alarm voltage set points, verify signal voltage once high voltage limit is reached (HVLIM)
      Warnings:
      200-240 volt units 384 w/o brake — 405 w/brake ±5%
      380-500 volt units 801 w/o brake — 840 w/brake ±5%
      Alarms:
      200-240 volt units 425 volts DC ±5%
      380-500 volt units 855 volts DC ±5%
   b) Verify the DC Link Voltage (UNIV)
      [256 • (meter voltage) = DC Bus voltage]
6) Turn the potentiometer full clockwise and open the switch (up position).
7) For SB and EB drives only, change parameter 400 to Resistor. A resistor must be hooked up to the drives R+ and R– terminals.
8) Close the Over Volt Test switch (down position).
9) Monitoring the voltage in the display, increase the DC Link Voltage by turning the potentiometer counter clockwise.
   a) Check Brake operation and verify signal (DBGATE DBRTON)
      ~795vDC Brake turn on voltage (380-500 volt units)
      ~390vDC Brake turn on voltage (200-240 volt units)
10) Upon completion of tests turn the potentiometer fully clockwise and open the switch (up position).
11) Return all parameters to original settings.

Test Points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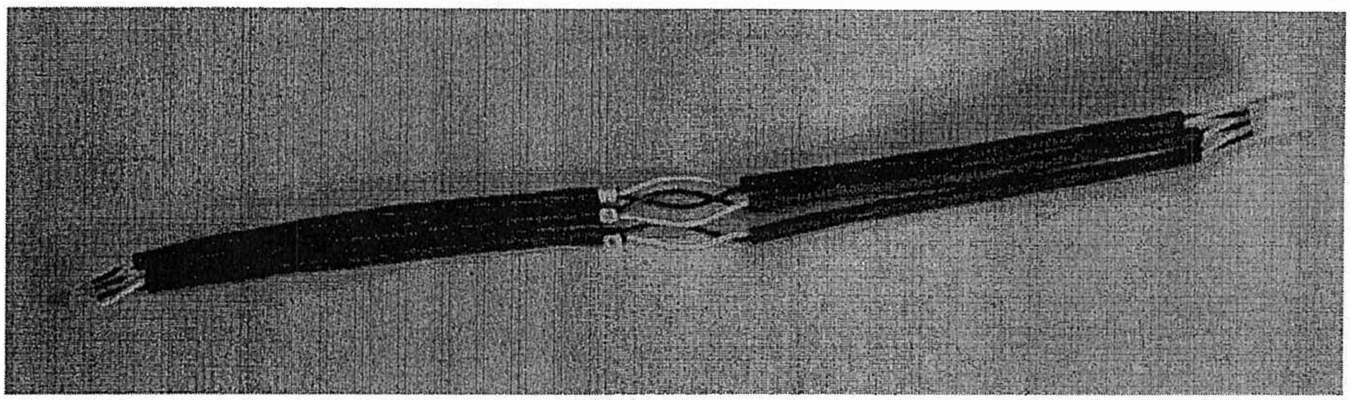
BWN
BWP
BVN
BVP
BUN
BUP
+5volt
R1
D1
+14volt
R2
D2
–14volt
IU1
IV1
IW1
R4
IU
IV
IW
DBGATE
DBRTON
OTFLT
INRUSH
SYNC
Fan Test
S1
FAN-ON
HI-LOW
SCR-DIS
Inverter Disable
S2
HVLIM
UINV
Overvoltage Test
S3
TEMP
D4
C1
R5
+24volt
R3
D3
VCXO
GX

SCR Gate Driver Test Cable

The SCR Gate Driver Test Cable gives the technician the ability to breakout and extend the length of the cable supplying the gate signals from the power/IF cards to the SCR's. The breakout enables the technician access to the gate signal wires away from high voltages (both AC input and DC bus) and a 2 inch gap in the shield enables proper placement of test equipment . By using a clamp-on current probe, attached to an oscilloscope, the proper firing signals of SCR can be both verified and measured. With out this cable the ability to verify the proper firing of the SCR's is next to impossible due to the close proximity of components in the drives.



Installation

Once the voltages are removed the SCR gate lead connection needs to be removed. This is done by removing:

MK14 -VLT 3060-3250 500 Volt, VLT 3032-3052 200 Volt
MK6 -VLT 5060-5250 500 Volt, VLT 5032-5052 200 Volt, VLT 5075-5300 Aqua 460 Volt, VLT 5042-5062 Aqua 200 Volt, VLT 6075-6275 460 Volt VLT 6042-6062 200 Volt
MK5 - VLT 5300-5500 500 Volt, VLT 5350-5600 Aqua 460 Volt, VLT 6350-6550 460 Volt

Now, proceed by plugging the SCR Gate Driver Test Cable into the applicable MK connector on the power/IF card. The other end is then plugged into the original SCR gate lead closing the loop from the SCR's to the power/IF card. Once the cable is hooked up use a current probe and an oscilloscope connecting the probe around the white wire of the SCR Gate Driver Test Cable. Now it is time AC power can be reconnected and the proper gate signal wave form can be verified.

The current pulse should have a waveform as shown at left with:

A1 > 1.1 A

A2 > 0.40 A

T1> 300 µs

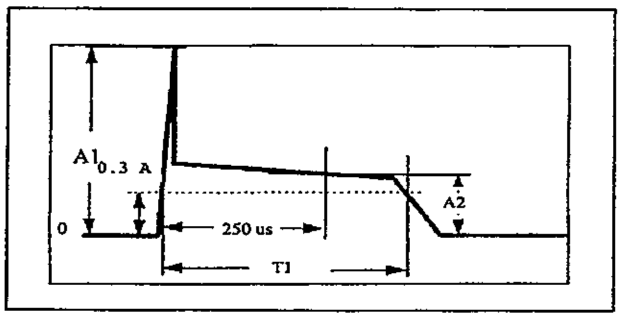


Figure 1: SCR Gate Current Pulse Waveform

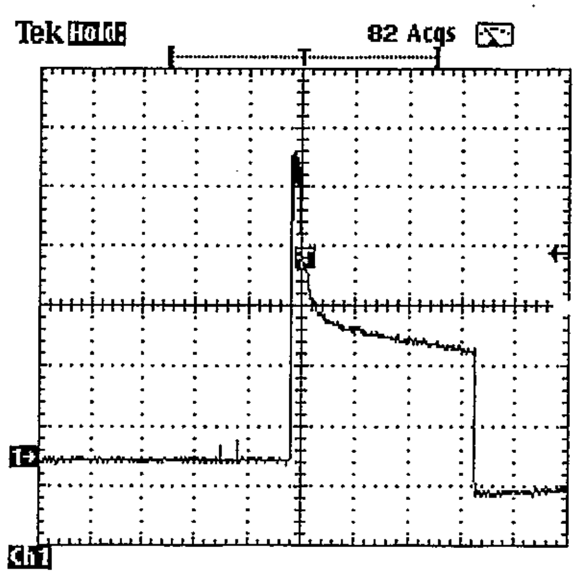


Figure 2: SCR Gate Current Pulse Waveform with a 112 Amp load.

Power Card DC Supply Source

The Power Card DC Supply Source is an alternate means of powering up the inverter section of the VLT without applying DC bus voltage to the remainder of the unit. In VLT 5000, 6000 and 5000 AQUA Series units, it also makes it possible to power the inverter section while the capacitor bank is removed. This can be helpful in troubleshooting, enabling the technician to make a variety of tests without the risk of damage or injury due to a fully charged DC bus. One such example is the ability to test IGBT gate drive signals right at the IGBT connection. Such a test can only be made with the capacitor bank removed and the power card powered from an alternative source. The Power Card DC Supply Source does not in itself perform any diagnostic tests.

Safety Notice

Keep in mind the voltage levels in the drive are still maintained through the Power Card DC Supply Source. Both AC and DC voltage are present in the drive while servicing, so close attention is required to prevent either personnel injury and/or equipment damage. The use of the Power Card DC Supply Source should be done by a qualified technician familiar with the voltage levels inside the VLT.

VLT 5000, 6000 and 5000 AQUA Installation

For Power Card DC Supply Source installation in the following drives:

VLT 5060-5250
VLT 5032-5052 (230 VAC)
VLT 5075-5300 AQUA
VLT 5042-5062 (230 VAC) AQUA
VLT 6075-6275
VLT 6042-6062 (230 VAC)

Note: After the AC voltage is removed and prior to servicing, all voltages (AC and DC) should be verified with a meter.

1. Disconnect power to the drive. Wait at least 15 minutes after AC voltage is disconnected before servicing to ensure the DC bus capacitors are fully discharged.
2. Remove DC capacitor bank, if necessary, to perform test on drive. When removing DC capacitor bank, follow these instructions dependent on enclosure type:
   - **NEMA 12** - Remove the DC+ and DC- leads coming from the DC link inductor to the top of the capacitor bank (See Figure 5). Ensure these leads are taped off and adequately insulated to protect personnel and equipment.
   - **Chassis and NEMA 1** - Remove the two Torx head screws from the DC link inductors while keeping the wire assemblies attached to the DC bus assembly (See Figure 5). It may be easier to first remove these wires from the DC capacitor bank, then remove the two Torx head screws.

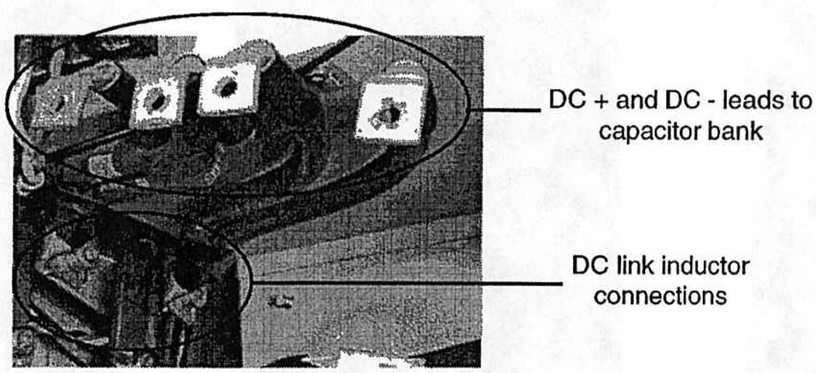


Figure 5. DC capacitor bank connections

3. Remove the three soft charge fuses from the soft charge fuse block (See Figures 6 and 7).

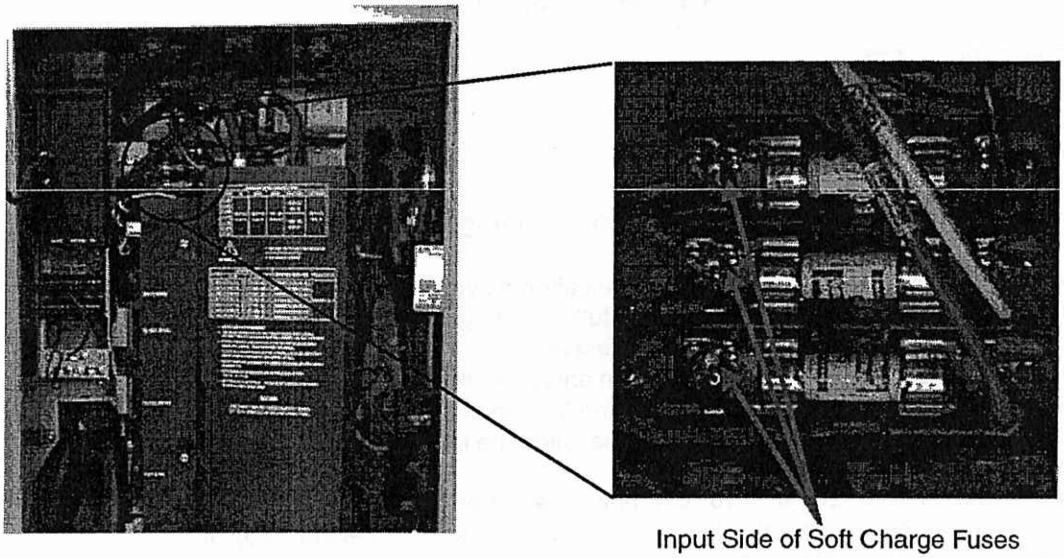


Figure 6. Soft charge fuses - Horizontal Mount

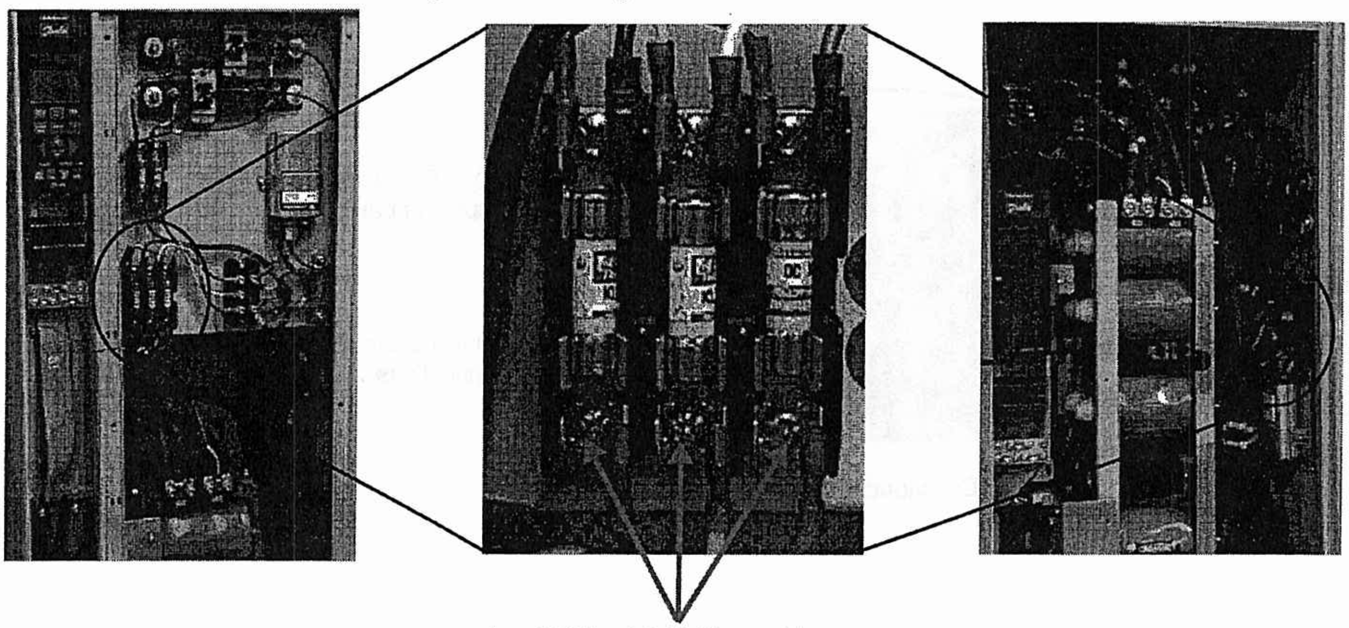
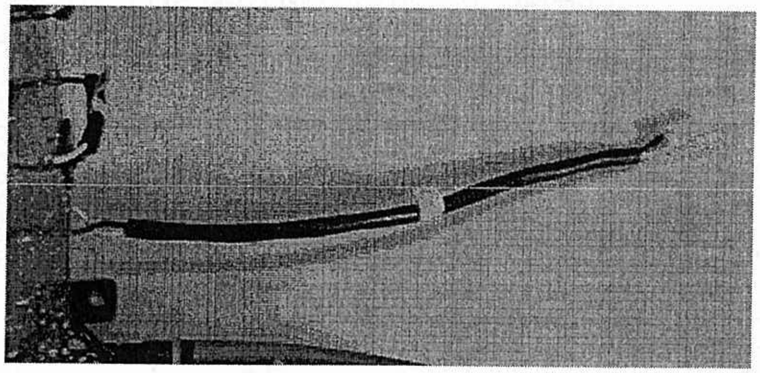


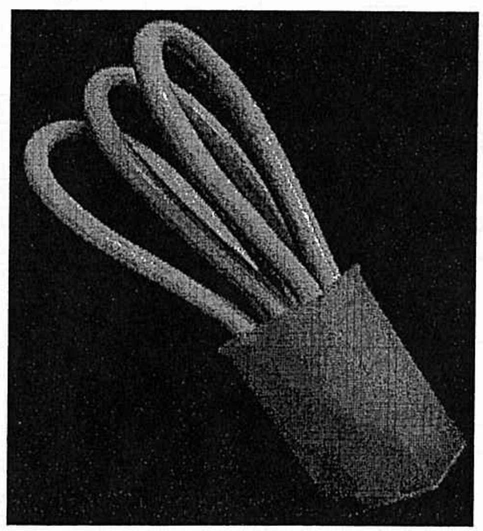
Figure 7. Soft charge fuses - Vertical Mount

4. Connect the VLT 5000/6000 wire harness assembly, supplied with the Power Card DC Supply Source, to the common connector at the bottom of the Power Card DC Supply Source box.
5. Connect the three fast-on connectors to the input side (left side or bottom end) of the soft charge fuse block (See Figures 6 and 7).

6. Connect the DC bus connections of the Power Card DC Supply Source to the 3-pin Molex connector attached to the Power Card.



7. Remove the SCR cable assembly from MK6 of the Power Card.
8. Short the SCR Gate-Cathode connections by inserting the SCR Jumper Plug into the end of the MK6 cable (See Figure 9).



9. Reapply power and perform necessary tests.

SPARE PARTS LIST
VLT 5060 - 5250 380/500V, 5075 - 5300 Aqua, 6075 - 6275 380/460V

DESCRIPTION	5060 Aqua 5075 6075	5075 Aqua 5100 6100	5100 Aqua 50125 6125	5125 Aqua 5150 6150	5150 Aqua 5200 6175	5200 Aqua 5250 6225	5250 Aqua 5300 6275
Control Card, Process, includes software	176F1400	176F1400	176F1400	176F1400	176F1400	176F1400	176F1400
Control Card, Process (conformal coated)	176F1452	176F1452	176F1452	176F1452	176F1452	176F1452	176F1452
Control Card, HVAC/Aqua, includes software	176F1405	176F1405	176F1405	176F1405	176F1405	176F1405	176F1405
Control Card, AQUA/HVAC (conformal)	176F1453	176F1453	176F1453	176F1453	176F1453	176F1453	176F1453
Local Control Panel Process	175Z0401	175Z0401	175Z0401	175Z0401	175Z0401	175Z0401	175Z0401
Local Control Panel HVAC/Aqua	175Z7804	175Z7804	175Z7804	175Z7804	175Z7804	175Z7804	175Z7804
Power Card ST/HVAC/Aqua Revised	176F1466	176F1467	176F1468	176F1469	176F1470	176F1471	176F1472
Power Card ST/HVAC/Aqua Rev CONF	176F2349	176F2350	176F2351	176F2352	176F2353	176F2354	176F2355
Power Card EB Revised	176F1473	176F1474	176F1475	176F1476	176F1477	176F1478	176F1479
Power Card EB Revised Conformal	176F2356	176F2357	176F2358	176F2359	176F2360	176F2361	176F2362
Brake Snubber Card	176F1122	176F1122	176F1122	176F1123	176F1123	176F1124	176F1124
Brake Snubber Card Conformal	176F2446	176F24446	176F2446	176F2447	176F2447	176F2448	176F2448
IGBT Snubber Card						176F1121	176F1121
IGBT Snubber Card Conformal						176F2460	176F2460
DC Bus RFI Filter Card	176F1187	176F1187	176F1187	176F1187	176F1187	176F1187	176F1187
DC Bus RFI Filter Card Conformal	176F2458	176F2458	176F2458	176F2458	176F2458	176F2458	176F2458
IGBT Assembly	176F1125	176F1125	176F1126			176F1129	176F1129
IGBT Assembly, Conformal	176F2402	176F2402	176F2403				
IGBT Assembly, Lower				176F1127	176F1127		
IGBT Assembly, Lower Conformal				176F2405	176F2405		
IGBT Assembly, Upper				176F1128	176F1128		
IGBT Assembly, Upper Conformal				176F2404	176F2404		
Brake IGBT	176F1130	176F1130	176F1130	176F1131	176F1131	176F1132	176F1132
SCR/Diode Input Rectifier	176F1133	176F1134	176F1135	176F1136	176F1137	176F1138	176F1139
DC Bus Capacitor	176F1139	176F1139	176F1139	176F1139	176F1139	176F1139	176F1139
Mylar Insulator, DC Capacitor Bank	176F1321	176F1321	176F1321	176F1323	176F1323	176F1325	176F1325
Bus Plate +, DC Capacitor Bank	176F1290	176F1290	176F1290	176F1293	176F1293	176F1296	176F1296
Bus Plate -, DC Capacitor Bank	176F1291	176F1291	176F1291	176F1294	176F1294	176F1297	176F1297
Bus Plate +/-, DC Capacitor Bank	176F1292	176F1292	176F1292	176F1295	176F1295	176F1298	176F1298
Bottom Insulator, DC Capacitor Bank	176F1322	176F1322	176F1322	176F1324	176F1324	176F1326	176F1326
Front Shield, DC Cap Bank, IP54/N12	176F1287	176F1287	176F1287	176F1288	176F1288	176F1289	175F1289
Front Shield, DC Cap Bank, IP20/N1	176F1357	176F1357	176F1357	176F1358	176F1358	176F1359	176F1359
Front Shield, Soft Charge, IP20/N1	176F1360	176F1360	176F1360	176F1361	176F1361	176F1361	176F1361
DC Bus Capacitor Bank Assembly	176F1275	176F1276	176F1277	176F1278	176F1279	176F1280	176F1281
Current Sensor Assy IP20/CHM/N1	176F1140	176F1140	176F1140				
I Sensor Assy IP20/CHM/N1 CONF	176F2400	176F2400	176F2400				
Current Sensor Assy IP54/N12, Pkg of 3	176F1143	176F1143	176F1143				
I Sensor Assy IP54/N12, Pkg of 3 CONF	176F2401	176F2401	176F2401				
Current Sensor				176F1141	176F1141		
Current Sensor Conformal				176F2461	176F2461		
Current Sensor IP54						176F1142	176F1142
Current Sensor IP54 Conformal						176F2462	176F2462
Current Sensor w/Output Wire (U) IP20						176F1488	176F1488
I Sensor w/Output Wire (U) IP20 Conformal						176F2463	176F2463
Current Sensor w/Output Wire (V) IP20						176F1489	176F1489
I Sensor w/Output Wire (V) IP20 Conformal						176F2464	176F2464
Current Sensor w/Output Wire (W) IP20						176F1490	176F1490
I Sensor w/Output Wire (W) IP20 Conformal						176F2465	176F2465
DC Bus Balance Resistor	176L3423	175L3423	175L3423	175L3423	175L3423	175L3550	175L3550
SCR Snubber Capacitor	175L3424	175L3424	175L3424	175L3424	175L3424	175L3424	175L3424
SCR Snubber Resistor	176F1145	176F1145	176F1145	176F1145	176F1145	176F1145	176F1145
Heatsink Thermal Sensor Assembly	176F1273	176F1273	176F1273	176F1273	176F1273	176F1273	176F1273
Soft Charge Rectifier	175L3421	175L3421	175L3421	176F1146	176F1146	176F1146	176F1146
Soft Charge Resistor, include thermostat	176F1144	176F1144	176F1144	176F1144	176F1144	176F1144	176F1144
Soft Charge Rectifier Fuse, Pkg of 3	176F1147	176F1147	176F1147	176F1148	176F1148	176F1148	176F1148
Soft Charge Rectifier Fuse Block	175L3418	175L3418	175L3418	175L3418	175L3418	175L3418	175L3418
SCR Snubber Diode	176F1343	176F1343	176F1343	176F1343	176F1343	176F1343	176F1343
Soft Charge Resistor Fuse	176F1192	176F1192	176F1192	176F1192	176F1192	176F1192	176F1192

SPARE PARTS LIST
VLT 5060 - 5250 380/500V, 5075 - 5300 Aqua, 6075 - 6275 380/460V Continued

DESCRIPTION	5060 Aqua 5075 6075	5075 Aqua 5100 6100	5100 Aqua 50125 6125	5125 Aqua 5150 6150	5150 Aqua 5200 6175	5200 Aqua 5250 6225	5250 Aqua 5300 6275
Soft Charge Resistor Fuse Block	176F1193	176F1193	176F1193	176F1193	176F1194	176F1194	176F1194
DC Link Inductor IP20/CHM/N1	176F2324	176F2328	176F2332	176F2336	176F2340	176F2343	176F2345
DC Link Inductor IP54/N12	176F2326	176F2330	176F2334	176F2338	176F2342	176F2346	176F2348
Output Inductor IP20/CHM/N1	176F2323	176F2327	176F2331	176F2335	176F2339	176F2344	176F2344
Output Inductor IP54/N12	176F2325	176F2329	176F2333	176F2337	176F2341	176F2347	176F2347
Fan, Heatsink IP20/CHM/N1	176F1177	176F1177	176F1177	176F1178	176F1178	176F1178	176F1178
Cap, Fan Heatsink IP20/CHM/N1/IP54/N1	176F1179	176F1179	176F1179	176F1180	176F1180	1876F1180	176F1180
Inlet Ring, Heatsink Fan, IP20/N1/CHM				176F2397	176F2397	176F2397	176F2397
Fan Assy. Heatsink IP54/N12	176F1181	176F1181	176F1181	176F1182	176F1182	176F1182	176F1182
Fan, Cap Bank IP54/N12	176F1245	176F1245	176F1245				
Fan, Cap Bank IP54/N12 Conformal	176F2457	176F2457	176F2457				
Fan, Door, Lower IP54/N12				176F1184	176F1184	176F1184	176F1184
Fan, Door, Upper IP54/N12				176F1223	176F1223	176F1223	176F1223
Fan Guard, Upper IP54/N12				176F1224	176F1224	176F1224	176F1224
Autotransformer, Fan Supply	176F1243	176F1243	176F1243	176F1244	176F1244	176F1244	176F1244
Filter, Door Fan IP54/N12				176F1185	176F1185	176F1185	176F1185
Grill, Door Fan IP54/N12, includes filter				176F1186	176F1186	176F1186	176F1186
SMPS Fuse	175L3437	175L3437	175L3437	175L3437	175L3437	175L3437	175L3437
Terminals, Line	176F1188	176F1188	176F1188	176F1189	176F1189	176F1189	176F1189
Terminals, Motor	176F1190	176F1190	176F1190	176F1191	176F1191	176F1191	176F1191
Terminals, Brake (SB/EB Only)	176F1212	176F1212	176F1212	176F1213	176F1213	176F1213	176F1213
Terminals, DC (EB Only)	176F1214	176F1214	176F1214	176F1215	176F1215	176F1215	176F1215
Terminal Kit, Control Card	176F1210	176F1210	176F1210	176F1210	176F1210	176F1210	176F1210
Terminal Kit, Power Card	176F1211	176F1211	176F1211	176F1211	176F1211	176F1211	176F1211
Terminals, Aux Fan Supply, HVAC/Aqua	176F1338	176F1338	176F1338	176F1338	176F1338	176F1338	176F1338
DC Terminal Repair Kit, Cap Bank	176F2381	176F2381	176F2381	176F2382	176F2382	176F2382	176F2382
Top Cover IP20/CHM/N1	176F1263	176F1263	176F1263	176F1264	176F1264	176F1264	176F1264
Front Door w/Screws IP20/CHM/N1	176F1266	176F1266	176F1266	176F1267	176F1267	176F1267	176F1267
Front Cover (Plas) Process IP20/CHM/N1	176F1268	176F1268	176F1268	176F1265	176F1265	176F1265	176F1265
Front Cover (Plas) HVAC IP20/CHM/N1	175Z3010	175Z3010	175Z3010	176F1339	176F1339	176F1339	176F1339
Front Cover (Plas) Aqua IP20/CHM/N1	176F1348	176F1348	176F1348	176F1349	176F1349	176F1349	176F1349
Front Logo (Plastic) IP20/CHM/N1	175Z3001	175Z3001	175Z3001	175Z3001	175Z3001	175Z3001	175Z3001
Front Door w/Hardware Process IP54/N12	176F1269	176F1269	176F1269	176F1328	176F1328	176F1270	176F1270
Front Door w/Hardware HVAC IP54/N12	176F1340	176F1340	176F1340	176F1341	176F1341	176F1342	176F1342
Front Door w/Hardware Aqua IP54/N12	176F1353	176F1353	176F1353	176F1354	176F1354	176F1355	176F1355
Hinge Kit, Front Door IP54/N12	176F1216	176F1216	176F1216	176F1216	176F1216	176F1216	176F1216
Latch Kit, Front Door IP54/N12	176F1217	176F1217	176F1217	176F1218	176F1218	176F1218	176F1218
Bottom Access Plate Assy. IP20/IP54	175L3592	175L3592	175L3592	175L3592	175L3592	175L3592	175L3592
Conduit Bracket IP20/CHM/N1	176F1246	176F1246	176F1246	176F1247	176F1247	176F1247	176F1247
Display Cradle IP20/CHM/N1	175Z1158	175Z1158	175Z1158	175Z1158	175Z1158	175Z1158	175Z1158
Control Card Cassette	176F1240	176F1240	176F1240	176F1240	176F1240	176F1240	176F1240
Control Card Mtg. Bracket IP55/N12	176F1299	176F1299	176F1299	176F1299	176F1299	176F1299	176F1299
Power Card Bracket Top	176F1259	176F1259	176F1259	176F1261	176F1261	176F1261	176F1261
Power Card Bracket Bottom	176F1260	176F1260	176F1260	176F1262	176F1262	176F1262	176F1262
Ribbon Cable Set, IP20/CHM/N1	176F1225	176F1225	176F1225	176F1226	176F1226	176F1226	176F1226
Ribbon Cable Set, IP54/N12	176F1227	176F1227	176F1227	176F1228	176F1228	176F1228	176F1228
RFI Assembly, IP20/CHM/N1	176F1201	176F1201	176F1201	176F1202	176F1202	176F1203	176F1203
RFI Assembly, IP20/CHM/N1 Conformal	176F2451	176F2451	176F2451	176F2452	176F2452	176F2453	176F2453
RFI Assembly, IP54/N12	176F1282	176F1282	176F1282	176F1283	176F1283	176F1284	176F1284
RFI Assembly, IP545/N12 Conformal	176F2454	176F2454	176F2454	176F2455	176F2455	176F2456	176F2456
Soft Change Thermostat	176F1274	175F1274	176F1274	176F1274	176F1274	176F1274	176F1274
Bus Bar SCR +	176F1285	176F1285	176F1256	176F1253	176F1253	176F1251	176F1251
Bus Bar SCR -	176F1286	176F1286	176F1255	176F1254	176F1254	176F1252	176F1252
Bus Bar SCR AC	176F1257	176F1257	176F1257			176F1248	176F1248
Kit, SCR Bus Bar Insulator	176F1494	176F1494	176F1494	176F1494	176F1494	176F1494	176F1494
Bus Bar IGBT E-1-C2				176F1249	176F1249	176F1250	176F1250
Barrel Lug, Screw terminal, IP54/N12	176F2386	176F2386	176F2386				
Lifting Hook	176F1258	176F1258	176F1258	176F1258	176F1258	176F1258	176F1258

SPARE PARTS LIST

VLT 5060 - 5250 380/500V, 5075 - 5300 Aqua, 6075 - 6275 380/460V Continued

DESCRIPTION	5060 Aqua 5075 6075	5075 Aqua 5100 6100	5100 Aqua 50125 6125	5125 Aqua 5150 6150	5150 Aqua 5200 6175	5200 Aqua 5250 6225	5250 Aqua 5300 6275
Cable Assy. Control to LCP IP54/N12	176F1220	176F1220	176F1220	176F1221	176F1221	176F1221	176F1221
Wire Assy. Pwr Card to SCR	176F1229	176F1229	176F1230	176F1231	176F1231		
Wire Assy. Pwr to SCR IP20/CHM/N1						176F1232	176F1232
Wire Assy. Pwr Card to SCR IP54/N12						176F1233	176F1233
Wire Assy. Pwr to I Sense IP54/N12				176F1234	176F1234	176F1234	176F1234
Wire Kit, Input to SCR, incl 3 Phases IP20	176F2372	176F2372	176F2372	176F1486	176F1486	176F2374	176F2374
Wire Kit, Input to SCR, incl 3 Phases IP54	176F2373	176F2373	176F2373	176F1487	176F1487	176F2375	176F2375
Wire Kit, Motor Coil to Output Terminals, incl. 3 Phases IP20	Use 176F1140	Use 176F1140	Use 176F1140	176F2370	176F2370	Use 176F1488 176F1489 176F1490	Use 176F1488 176F1489 176F1490
Wire Kit, Splicer Block to Output Terminals, incl 3 Phases IP54	176F2385	176F2385	176F2385	176F2371	176F2371	176F2369	176F2369
Splicer Block for Output Wires IP54	176F2383	176F2383	176F2383	176F2383	176F2383	176F2384	176F2384
Wire Assy, MK7-Cap Bank Fans IP54/N12	176F1493	176F1493	176F1493				
Wire Assembly, MOV1	176F1464	176F1464	176F1464	176F1465	176F1465	176F1465	176F1465
Wire Assy, Pwr to I Sense IP20/CHM/N1				176F1235	165F1235	176F1235	176F1235
SPARE, WIRE Assy SFT CH							176F2387
SPARE, WIRE Assy R13 Soft Charge							176F2388
SPARE, WIRE Assy L1-Cap							176F2389
SPARE, WIRE Assy L1-Cap							176F2390
SPARE, WIRE Assy DC Bus							176F2391
SPARE, WIRE Assy +Bus to R							176F2392
SPARE, WIRE Assy -Bus to R							176F2393
SPARE, BUS Bar 400A Brake option							176F2394
SPARE, WIRE Assy BR2 to F4							176F2395
SPARE, WIRE Assy BR2 to R1							176F2396
EMC Ground Plate Chassis	176F5453	176F5453	176F5453	176F5454	187F5454	176F5454	176F5454

Danfoss Drives
4401 N. Bell School Road
Loves Park, IL. 61111
Phone TollFree: 800/432-6367
Phone: 815/639-8600
Fax: 815/639-8000

Danfoss

Table of Contents

Introduction

Section One

Section Two

Section Three

Section Four

Section Five

Section Six

Appendix

INTRODUCTION

The purpose of this manual is to provide technical information and instructions that will enable the user to identify faults and affect repairs on the following Danfoss Series 3000 and 3500 Adjustable Frequency Drives:

VLT 3002-3022, 230V VLT 3502-3532, 230V
VLT 3002-3052, 380, 460V VLT 3502-3562, 380, 460V

The manual has been divided into five sections. The first section covers the description and sequence of operations. Section two covers fault messages and provides troubleshooting charts both in the form of flow and symptom/cause. Section three describes the various tests and methods used to evaluate the drives' condition. Section four covers the removal and replacement of the various components. Section five discusses application-specific information.

ESD SAFETY

Electrostatic discharge. Many electronic components are sensitive to static electricity. Voltages so low that they cannot be felt, seen or heard can reduce the life, affect performance, or completely destroy sensitive electronic components.

When performing service, proper ESD equipment should be used to prevent possible damage from occurring.

WARNING:

The Adjustable Frequency Drive (AFD) contains dangerous voltages when connected to the line voltage. Only a competent technician should carry out the service.

FOR YOUR SAFETY:

1) DO NOT touch the electrical parts of the AFD when the AC line is connected. After the AC line is disconnected wait at least 15 minutes before touching any of the components.
2) When repairs or inspection is made the AC line must be disconnected.
3) The STOP key on the control panel does not disconnect the AC line.
4) During operation and programming of the parameters the motor may start without warning. Activate the STOP key when changing data.

TOOLS REQUIRED:

The following tools will be sufficient to troubleshoot and repair all units covered by this manual:

Digital multi-meter
Clamp-on ammeter
Analog voltmeter
Flat head screw drivers
Phillips screw drivers
Torx drivers - T10, T15, T20, T27
Socket 7mm
Pliers
Torque wrench

DESCRIPTION OF OPERATION

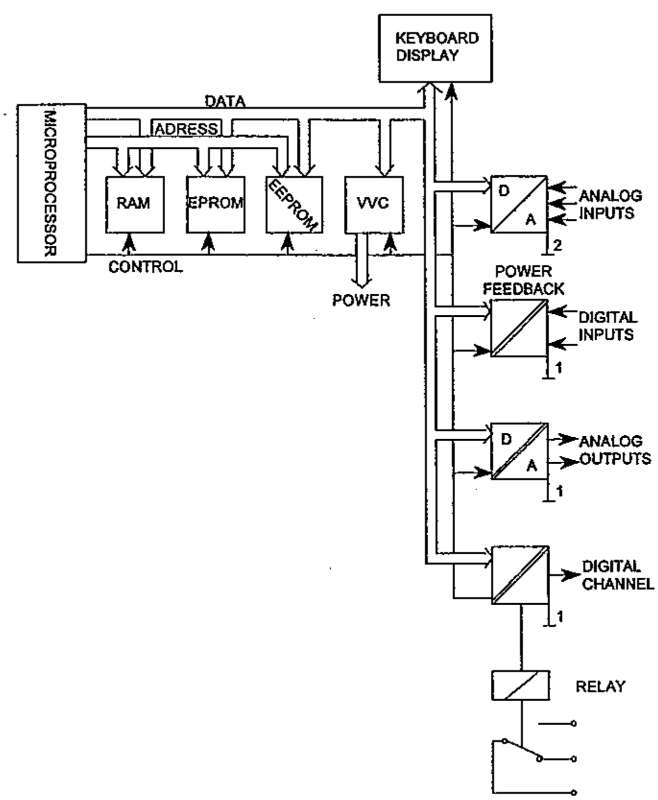
Refer to the overall schematic in the Appendix.

This manual in not intended to give a detailed description of the unit's operation. It is intended to provide the reader a general overview of the function of each of the unit's main assemblies. With this information, the repair technician should have a better understanding of the unit's operation and therefore aid in the troubleshooting process.

The VLT is divided primarily into three sections commonly referred to as: logic, interface, and power.

LOGIC SECTION

The control card contains the majority of the logic section. The heart of the control card is a microprocessor which controls and supervises all functions of the unit's operation. In addition, a separate PROM contains the parameter sets which characterize the unit and provide the user with the definable data enabling the unit to be adjusted to meet the customer's specific application. This definable data is then stored in an EEPROM which provides security during power-down and also allows flexibility for future changes as needed. A custom integrated circuit generates the PWM waveform which is then sent on to the Interface/ILD Card gate drive circuits.



Also, part of the logic section is the keyboard/display mounted on the control card. The keyboard provides the interface between the digital logic and the human programmer. The LCD (Liquid Crystal Display) provides the operator/programmer with menu selection, unit status and fault diagnostic information. Programming is accomplished through the use of four of the eight keys available on the keyboard. The additional four keys provide various local controls, depending on the type of unit.

A series of customer terminals are provided for the input of remote commands such as: Run, Stop and Speed Reference. Terminals are also provided to supply outputs to peripheral devices for the purpose of monitoring and control. Two programmable relay outputs are also available to interface the unit with other devices.

In addition, the control card is capable of communicating via a serial link with outside devices such as a personal computer or a programmable logic controller.

The control card provides two voltages for use from the customer terminal strip. The 24VDC is used primarily to control functions such as: Start, Stop and Forward/ Reverse. The 24VDC is provided from a separate section of the unit's power supply and is delivered to the control card from the Interface/ILD Card via the two conductor ribbon cable.

LOGIC SECTION

A 10VDC supply is also available for use as a speed reference when connected to an appropriate potentiometer. These two voltage references are limited in the amount of available current they can provide (see specifications in Instruction Manual). Attempting to power devices which draw currents in excess of that available may result in an eventual failure of the power supply. In addition, if the supply is loaded too heavily, sufficient voltage will not be available to activate the control inputs.

During the troubleshooting process it is important to remember that the control card can only respond to the commands it receives. It is also possible that due to a failure, the Control Card will not respond to control commands. For this reason it is necessary to isolate the fault to the control commands, control programming, or the drive itself. If, for example, the drive stops unexpectedly, the control commands should first be checked. This would include confirming that contact closures and analog input signals are present at the proper terminals of the drive. Never assume that a signal is present because it is supposed to be. A meter should be used to confirm the presence of signals at the drive terminals.

Secondly, the programming of the drive should be confirmed to insure that the terminals used are set to accept the signals connected. Each digital and analog input terminal can be programmed to respond in very different ways. If there is a concern whether the remote controls are functioning correctly it is possible to take local control of the drive to confirm proper operation. A word of caution here: prior to taking local control, insure that all other equipment associated with the drive is prepared to operate. In many cases safety interlocks are installed which can only be activated through the use of a normal remote control start.

As there must be a command in order for the Control Card to respond, there may also be situations where the Control Card displays unknown data or that performance may be affected such as in the case of speed instability. In these cases the first thought may be to replace the Control Card. However, this type of erroneous operation is usually due to electrical noise injected onto control signal wiring. Although the Control Card has been designed to reject such interference, noise levels of sufficient amplitude can, in fact, affect the performance of the Control Card. In these situations it is necessary to investigate the wiring practices used. For example, the control signal wiring should not be run in parallel with higher voltage wiring, including power, motor, and brake resistor leads. The reason being that voltages can be induced from one conductor onto another through capacitive or inductive coupling. This type of problem can be corrected by rerouting the wiring or through the use of shielded cable. When using shielded cable it is important to properly terminate the drain wire. The drain wire should be terminated only at the drive end of the cable. Specific termination points are provided on each unit. The opposite end of the shielded cable drain wire is then cut back and taped off to prevent it from coming in contact with other terminals or acting as an antenna.

LOGIC TO POWER INTERFACE

INPUT LINE DRIVER (ILD) CARD

The logic to power interface isolates the high voltage components of the power section from the low voltage signals of the logic section. This is accomplished by use of the Interface/ILD Card*. All communication between the control logic and the rest of the unit passes through the Interface/ILD Card. This communication includes: DC Bus voltage monitoring, line voltage monitoring, feedback from the current sensors, temperature sensing, and control of the gate drive firing signals. The Interface Card contains a Switch Mode Power Supply (SMPS) which provides the unit with 24VDC, ±13VDC, and 5VDC. The switch mode type supply is used due to its efficiency and linearity. Another benefit of the SMPS is that it uses the DC Bus voltage as a power source. In the event of a power loss the power supply remains active for a longer period of time versus conventional power supplies.

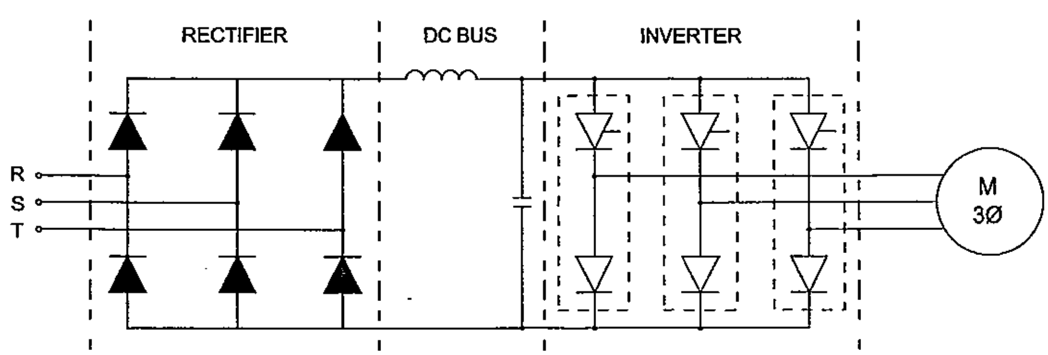
During the troubleshooting process it is important to determine whether the Interface Card is receiving or sending the signal that appears to be at fault. For example, the gate-drive signals are generated by the Interface Card. Conversely an over-temperature fault can result from the Interface Card receiving an "open" from the heatsink thermal switch. If the fault could stem from a signal received by the Interface Card, it is necessary to isolate the fault to either the signal source or the Interface/ILD card. It is critical to check all possibilities to avoid costly errors and long downtime. In any case, the Interface/ILD Card is relatively easy to change, so if it is suspect, a quick exchange will confirm a faulty board.

* The Input Line Driver (ILD) Card is used on VLT 3002-3004, 230V; VLT 3502-3504, 230V; VLT 3002-3008, 380V/460V, and VLT 3502-3511, 380V/460V. All other units covered by this manual use the Interface Card.

POWER SECTION

The power section contains the Rectifier, the DC Capacitor Bank and the IGBT power components. Also included in the power section are the DC Bus Coils and the Motor Coils. During the troubleshooting process, extreme care is required when probing into the power section components. The DC Bus voltage can rise well over 700VDC on 460V units. Although this voltage begins to decrease upon removal of input power, it can take up to fifteen minutes to discharge the DC Capacitor Bank to safe levels.

A fault in the power section will usually result in at least one of the customer provided line fuses being blown. Replacing fuses and re-apply power without further investigation is not recommended. The tests listed under Static Test Procedures in Section Three should be performed to insure that there are no shorted components in the power section. It is recommended that the motor leads be disconnected from the unit prior to re-applying power. This precaution opens the path for short circuit currents through the motor in case a faulty component remains.



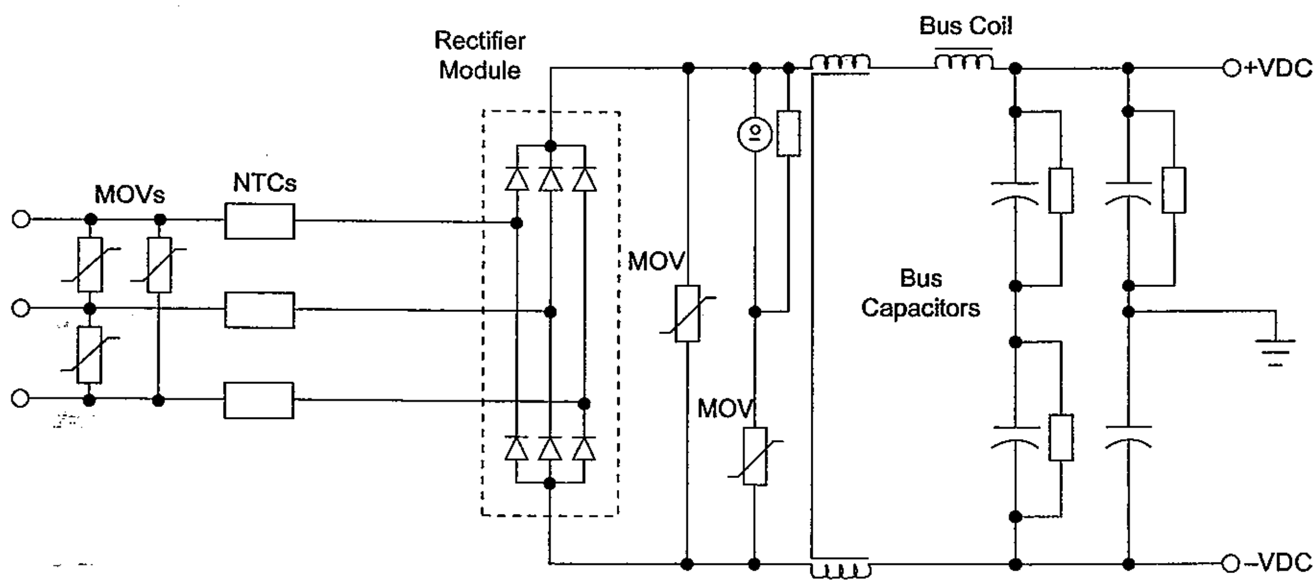
SIMPLFIED PWM POWER SECTION

SEQUENCE OF OPERATION

VLT 3002-3004, 230V, VLT 3002-3008, 380V/460V
VLT 3502-3504, 230V VLT 3502-3508, 380V/460V

When input power is first applied, the Rectifier Module converts the line voltage into a DC voltage. The rectified output is then connected to the DC Bus filter establishing a fixed DC Bus voltage. To limit the inrush charge current in the DC Bus capacitors, three Negative Temperature Coefficient (NTC) resistors are added in series with the inputs of the Rectifier Module. NTC resistors decrease in resistance as temperature increases. Providing that the charging process proceeds normally, the power supplies will come up and provide the Control Card with low voltage control power. At this time the Control Card display will indicate that the unit is ready for operation.

Following a run command and a speed reference, the Control Card delivers three Pulse Width Modulation (PWM) signals to the ILD Card. The ILD Card in turn receives these three signals and creates the six individually isolated gate drive signals. These gate pulses are fed directly to the Insulated Gate Bi-polar Transistor (IGBT) output power devices. The IGBTs are switched on and off to develop the PWM waveform which is ultimately delivered to the motor. As the unit operates, the ILD Card monitors the unit's operational status. Currents and voltages out of specified limits or excessive temperatures will result in the ILD Card responding to the fault. The ILD Card sends the appropriate fault message to the Control Card and in virtually all cases causes the unit to trip. Section 2 of this manual describes the fault messages and provides direction in determining the cause and the solution for the fault.



VLT 3006-3032, 230V, VLT 3011-3052, 380V/460V
VLT 3508-3532, 230V VLT 3511-3562, 380V/460V

When power is first applied, the normally open Bus Contactor forces the input line current to flow through the Positive Temperature Coefficient (PTC) resistors. PTC resistors increase in resistance as the temperature increases. The

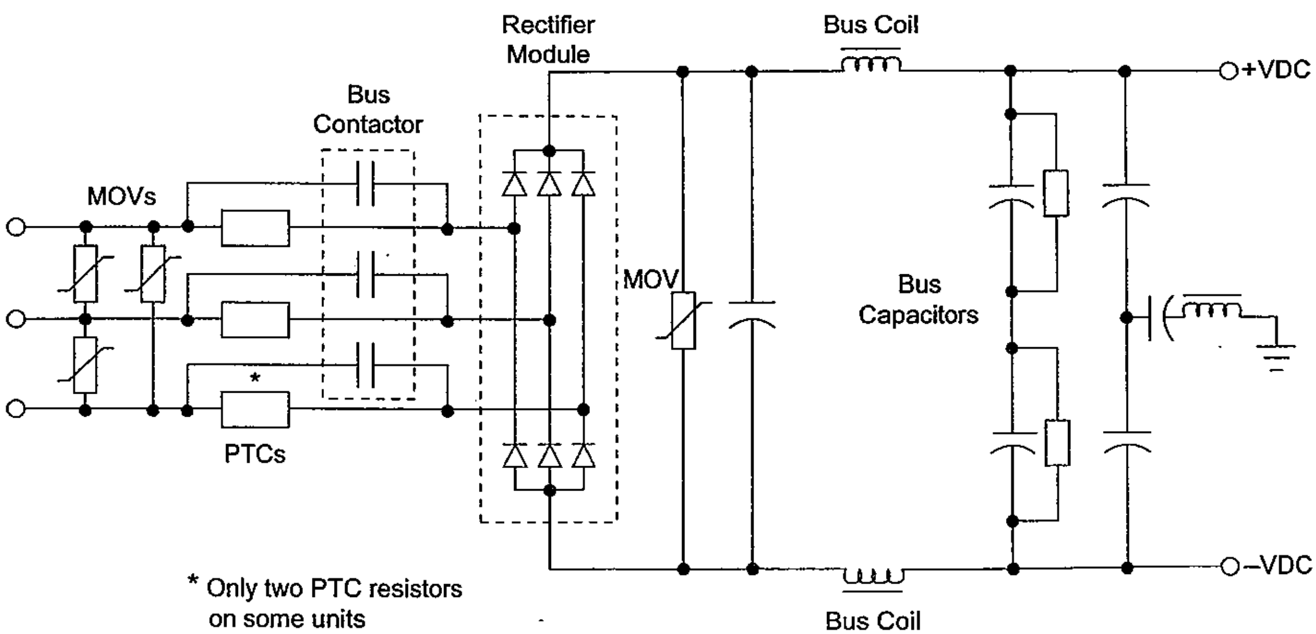
SEQUENCE OF OPERATION

PTC resistors are placed in series with the inputs of the Rectifier Module to limit the initial charge current of the DC Bus capacitors. The rectified line voltage is then applied to the DC Bus filter. As the DC Bus voltage increases, the Interface Card power supplies energize. As the power supplies stabilize, the Interface Card sends a signal to the Relay Card to pull in the Bus Contactor. The Relay Card energizes the contactor coil with a short burst of a high amplitude, full-wave rectified voltage to pull in the Bus Contactor. The Relay Card then switches the Bus Contactor coil voltage to a lower rectified holding voltage. As soon as the DC Bus Contactor closes, the PTC resistors are effectively removed from the circuit and the DC Bus Capacitors quickly finish charging. [1]

Providing that the charging process proceeds normally, the Interface Card power supplies will provide the Control Card with low voltage control power and the Control Card display will indicate that the unit is ready for operation.

Following a run command and a speed reference, the Control Card delivers a PWM signal (one per Phase) to the Interface Card. The Interface Card in turn receives these three signals and creates six individual isolated gate drive pulses. From here the gate pulses are fed directly to the Insulated Gate Bi-polar Transistor (IGBT) output power devices. The IGBTs are switched on and off to develop the PWM waveform which is ultimately delivered to the motor.

As the unit operates, the Interface Card monitors the unit's operational status. Currents and voltages out of specified limits or excessive temperatures will result in the Interface Card responding to the fault. The Interface Card sends the appropriate fault message to the Control Card and in virtually all cases causes the unit to trip. Section Two of this manual describes the fault messages and provides direction in determining the cause and the solution for the fault.



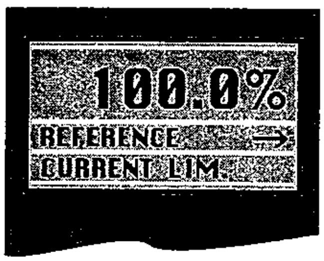
* Only two PTC resistors on some units

[1] The VLT 3511, 380/460V units have the Bus Contactor relay and PTC resistors mounted on the ILD Card.

FAULT INDICATORS AND MESSAGES

A variety of messages are displayed by the control card. Some messages indicate the operational status of the unit while others provide warnings of an impending fault. In addition, there are the alarm messages which indicate that the unit's operation has stopped due to a fault condition. In this section we will deal with only those messages which interrupt the unit's operation. A complete list of status messages can be found in the Instruction Manual. The particular type of status, warning, or alarm message will be indicated on the bottom line of the display.

STATUS MESSAGES



CURRENT LIMIT

This message will flash in the display when the unit is operating above the current limit setting as recorded in parameter 209. Parameter 310 may be set to provide a fixed time delay after which the unit will trip.

REF FAULT

This message will flash in the display should any live zero signal be operating outside of its range. For example, 4-20mA has been selected as the speed reference. Should the current loop be broken, the display will flash "REF FAULT". Parameters 414 and 415 may be used to select the unit's response to this condition.

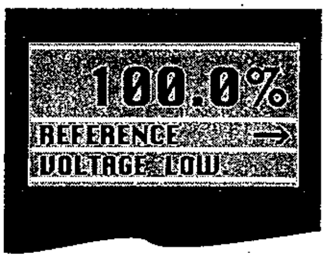
NO 24 VOLT

This message will flash if the 24 volt power supply is missing or out of tolerance. The 24 volt supply is used only for the customer's remote connections.

NO MOTOR

This message will flash if Motor Check has been activated in parameter 313, terminal 27 is enabled and no motor is detected.

WARNING MESSAGES



VOLTAGE LOW
This message will flash when the DC Bus voltage has fallen below the lower limit. This is an indication of low line voltage. This is only a warning message, however. If the condition persists, it will result in a unit trip on "Under Voltage".
* Refer to table for specific value.

VOLTAGE HIGH
This message will flash when the DC Bus voltage has exceeded the upper limit. This is an indication of high line voltage or regenerative energy being returned to the bus. This is only a warning message, however, if the condition persists, it will result in a unit trip on "Over Voltage".
* Refer to table for specific value.

INVERT TIME
This message will flash when the inverter ETR value has reached 98%. The inverter ETR (Electronic Thermal Relay) begins counting up as soon as the output current exceeds 105% of the unit's continuous current rating. At an inverter ETR value of 100%, the unit trips on "Invert Time".

MOTOR TIME
This message will flash if Motor Thermal Protection has been activated in parameter 315, "Warning" has been selected as the Data Value, and the Motor ETR value has reached 98%. The Motor ETR value begins counting up if the motor is run at slow speed or if the motor is consuming more than 116% of the motor's nominal rated current as entered in parameter 107. At a Motor ETR value of 100%, the unit will respond based on the setting in parameter 315. If Trip has been selected, the unit will trip on "Motor Time".

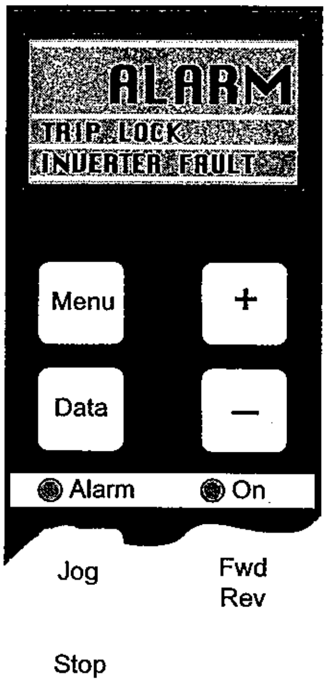
OVERCURRENT
This message indicates at least one of the three output phases has reached the unit's peak current rating. During this time the control card attempts to initiate current limit. If the current rises too fast or the control card cannot control the condition by means of current limit, the unit will trip on "Over Current".

* DC BUS VOLTAGE LIMITS

	VLT 3002-3052 VLT 3502-3562		
VLT Rating	230VAC	380VAC	460VAC
SMPS stop	190	360	360
SMPS start	210	410	410
Undervoltage trip, inverter stopped	210	400	460
inverter enabled	230	430	500
Control Card undervoltage warning	235	440	510
Control Card overvoltage warning	370	665	800
(brake applied*, parameter 300)	(395)	(705)	(845)
Overvoltage trip, inverter stopped	410	730	880
inverter enabled	380	680	820

* Only on VLT Series 3000 units.

ALARM MESSAGES



Alarm messages will be indicated by the following messages appearing in the display and the red Alarm LED will flash on the unit keypad. All alarm messages result in the unit's operation being interrupted and require a Manual or Automatic reset. Automatic reset can be selected in parameters 309 and 312. In addition, the message "Trip" or "Trip Locked" will be displayed. If "Trip Locked" is displayed, the only possible reset is to cycle power and then perform a manual reset. Manual reset is accomplished by means of the front panel push button or by a remote contact closure on the appropriate control terminal. Remedies listed with each alarm message give a basic description of the corrective action which can be taken to correct the fault condition. For a more detailed explanation, see the Symptom/Cause Section and the Application Section. Also note the numbers in parenthesis by each alarm message. These are the codes which will appear in the Fault memory, parameter 602.

INVERTER FAULT (1)

This message indicates a fault in the power section of the unit. This fault returns a "Trip Locked". Also see Testing The Inverter Section.

OVER VOLTAGE (2)

This message indicates the DC Bus voltage upper limit has been exceeded. This fault can be caused by high line voltage or regenerative energy being returned from the motor. To remedy this fault condition, reduce the line voltage or extend the Decel Ramp. This fault returns a "Trip". Also see Over Voltage Trips.

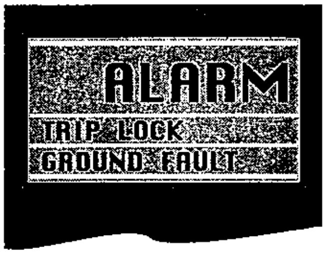
UNDER VOLTAGE (3)

This message indicates the DC bus voltage has fallen below the lower limit. To remedy this fault, increase the line voltage to the correct value for the unit rating. This fault returns a "Trip". Also see Testing the Soft Charge Circuit.

OVER CURRENT (4)

This message indicates a short circuit on the output of the inverter. This fault may also be caused by the unit reaching it's peak current rating so rapidly that the unit can not respond with current limit. An example may be running the drive at speed, and closing an output contactor connecting the drive to a high inertia load. To remedy this fault, check the output wiring and motor for short circuits. This fault returns a "Trip Locked". Also see Over Current Trips.

ALARM MESSAGES



GROUND FAULT (5)

This message indicates a leakage to ground on the output of the inverter. To remedy this fault, check the output wiring and motor for ground faults. It is also necessary to ensure that the VLT has been properly grounded. This fault returns a "Trip Locked". Also see Ground Fault Trips.

OVER TEMP (6)

This message indicates that the unit's heatsink temperature or the unit's internal ambient temperature has exceeded permissible limits. All units covered by this manual use a resetting thermal switch. The thermal switch is located on either the ILD Card or is mounted on the heatsink of units which use the Interface Card. To remedy the fault, correct the over temperature condition. This fault returns a "Trip." Also see Overtemp Trips.

INVERT TIME (7)

This message indicates the unit has delivered greater than 105% of the unit's continuous current rating for too long (inverse time function). Prior to this fault condition the "Invert Time" warning will be displayed. To remedy this fault, reduce the motor load to at or below the unit's continuous current rating. This fault returns a "Trip Locked". During the trip the counter will count down. Upon reaching 90%, the "Trip Locked" will change to "Trip".

MOTOR TIME (8)

This message indicates the motor has consumed greater than 116% of the value entered in parameter 107 (motor nominal current) for too long (inverse time function). This fault may also be caused from running the motor at a low speed and high current for too long a period of time. This trip will only occur if the "Motor Thermal Protection" has been activated in parameter 315. Prior to the trip the "Motor Time" warning will be displayed. To remedy this fault, reduce the load on the motor or raise the motor's speed. This fault returns a "Trip Locked". During the trip the counter will count down. Upon reaching 0% the "Trip Locked" will change to "Trip".

CURRENT LIMIT (9)

This message will be displayed if the unit has run in current limit for a time which exceeds the setting in parameter 310. To remedy this fault, reduce the motor's load or verify that the correct settings have been entered in parameter 209 (Current Limit) and parameter 310 (Current Limit Trip Delay). This fault returns a "Trip". See Current Limit Trips.

MOTOR TRIP (15)

This message will be displayed if parameter 400 is set to "Thermistor" and motor thermistor connected between terminals 50 and 16 has increased to a resistance of 3KΩ. To remedy this fault remove the motor over temperature condition. This fault returns a "Trip". The Reset Button can be held to allow access to the parameters.

EXCEPT FAULT

This fault is usually the result of electrical noise caused by a poor earth ground connection to the VLT. This fault may also be seen if Adaptive Motor Tuning is attempted on a motor many times larger than the drive rating (parameter 106). (This fault is accompanied by the PC address where an illegal value was found, also see page 4-1.)

GENERAL TROUBLESHOOTING TIPS

Prior to diving into a repair, here a few tips that if followed will make the job easier and may prevent unnecessary damage to good components.

1. First and foremost respect the voltages produced by the drive. Always verify the presence of line voltage and bus voltage before working on the unit. Also remember that some points in the drive are referenced to the negative bus and are at bus potential even though you may not expect it.

2. Never power up a unit which has had power removed and is suspected of being faulty. If a short circuit exists within the unit, applying power is likely to result in further damage. The safe approach is to conduct the Static Test Procedures. The static tests check all high voltage components for short circuits. The tests are relatively simple to make and can save money and downtime in the long run.

3. The safest method of conducting tests on the drive is with the motor disconnected. In this way a faulty component that was overlooked or the unfortunate slip of a test probe will generally result in a unit trip instead of further damage.

4. Following the replacement of parts, test run the unit with the motor disconnected. Start the unit at zero speed and slowly ramp the speed up until the speed is at least above 40 Hz. Monitor the phase to phase output voltage on all three motor terminals to check for balance (an analog voltmeter will work best here). If balanced the unit is ready to be tested on a motor. If not, further investigation is necessary.

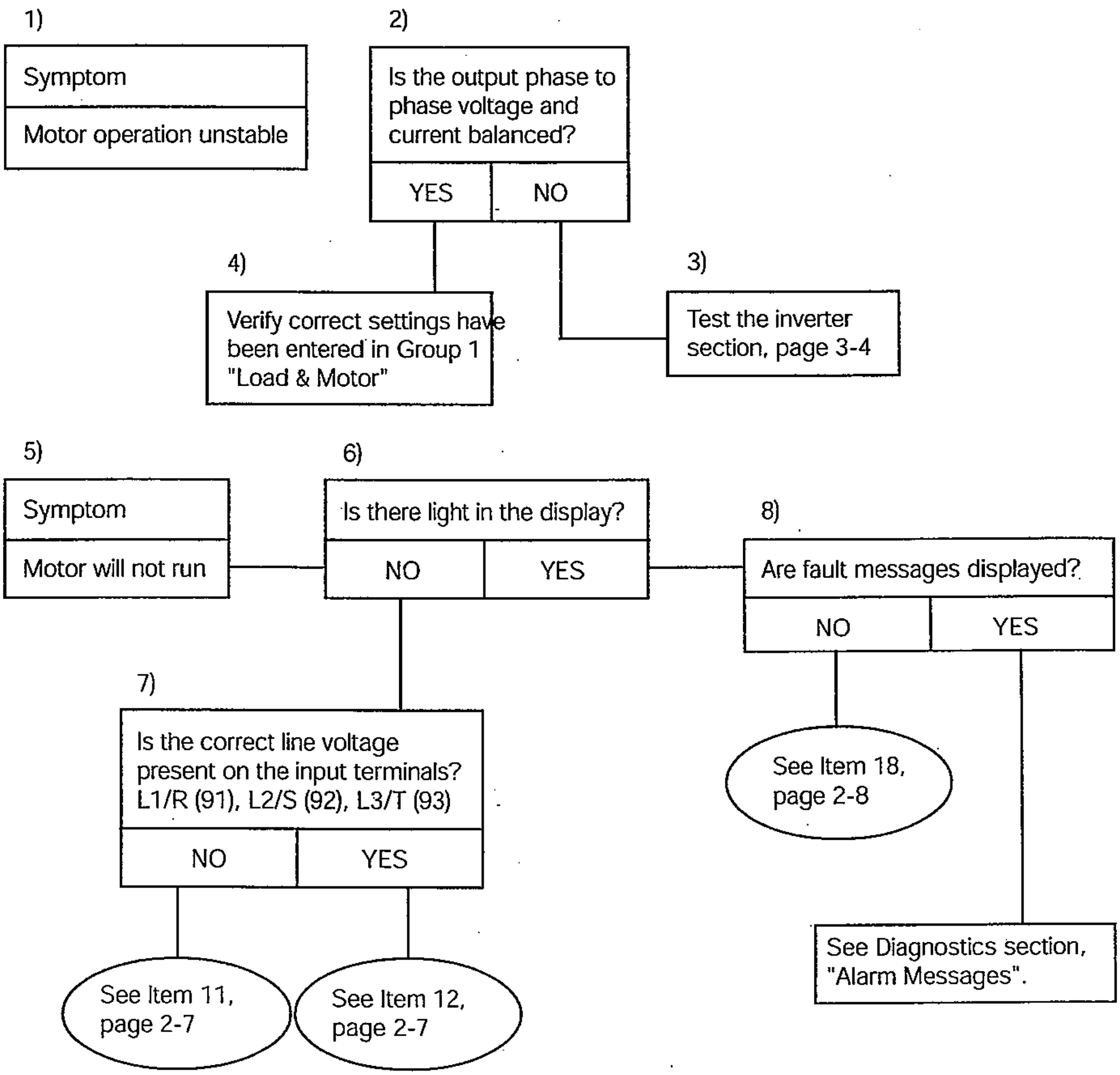
5. Never attempt to defeat fault protection devices within the drive. This will only result in unwanted component damage and may result in personal injury as well.

6. Always use factory approved replacement parts. The unit has been designed to operate within certain specifications. Incorrect parts may effect performance and result in further damage to the unit.

7. Read the instruction and service manuals. A thorough understanding of the unit is the best approach. If ever in doubt consult the factory or an authorized repair center for assistance.

VLT 3002-3022, 230V
VLT 3002-3052, 400/500V

VLT 3502-3532, 230V
VLT 3502-3562, 400/500V



9)

Symptom
No information in display

10)

Is the correct line voltage present on the input terminals? L1/R (91), L2/S (92), L3/T (93)

YES | NO

11)

Check Input Disconnect and fusing.

If fuses are blown, check for a short circuit in the Power Section.

12)

Disconnect all control signal plugs on the control card.

Does the fault disappear?

NO | YES

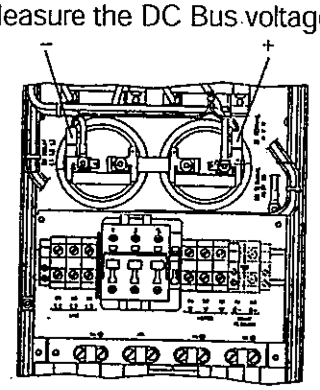
13)

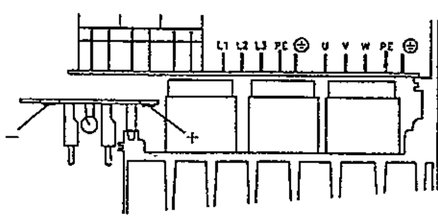
The fault may be caused by a short circuit in the control signals.

Check control wiring for proper connection.

14)

Is the DC Bus voltage OK? Should read 1.4 x the AC line V.
Measure the DC Bus voltage between terminal +VDC and –VDC.
Also refer to pages 3-1 and 3-2.





YES | NO

15)

Test the soft charge circuit, input rectifier, and DC Bus capacitors.

16)

Replace the Interface/ ILD Card.
Does the fault disappear?

YES | NO

Resume operation

17)

Replace the Control Card.
Does the fault disappear?

NO | YES

Replace the Relay Card

Resume operation

18) Motor stationary, info in display but no fault message displayed

19) Start VLT by pressing Start on the keypad.

20) Is the display frozen, i.e., the display cannot be changed or is undefinable?

NO → 22) | YES → 21)

21) Replace the Control Card, if this does not help, the fault might be electrical noise. Check whether the following precautions have been taken:
- Have shielded cables been used?
- Are the shields correctly terminated?
- Is the unit properly grounded to earth?

22) Is the motor connected correctly/

YES → 23) | NO → Correct the motor wiring.

Correct the motor wiring.

Insure motor overloads are reset and output contactor closed.

23) Try to run the VLT in local.
Refer to CAUTION at left.
Local control parameters.
On VLT Series 3000:
003 = Local
004 = Frequency reference change by means of + and –
On VLT Series 3500:
003 = keypad HOA
Press the Local/Hand key change speed by the + and –

Does the motor run?

YES → 24) | NO → 25)

CAUTION:
Prior to running in Local, insure all other equipment associated with the VLT is ready to function or has been isolated.

24) Verify that the control signals are connected to the correct terminals and the appropriate parameter settings have been entered.

25) Replace Control Card.

Does the motor run?

NO → 26)

26) Replace Interface/ILD Card.

Does the motor run?

NO → 27)

27) Consult factory.

SYMPTOM/CAUSE CHARTS

SYMPTOM/CAUSE charts are generally directed towards the more experienced technician. The intent of these charts is to provide a range of possible causes for a specific symptom. In doing so, these charts provide a direction, but with limited instruction.

SYMPTOM	POSSIBLE CAUSES
1. Control Card Display Is Not Lit.	Incorrect or missing input voltage
	Incorrect or missing DC bus voltage
	Remote control wiring loading the power supply
	Defective Control Card
	Defective Interface/ILD Card
	Defective Relay Card
	Defective or disconnected ribbon cables
2. Blown Input Line Fuses	Shorted Rectifier module
	Shorted IGBT
	Shorted DC Bus
	Shorted brake IGBT
	Mis-wired Dynamic Brake option
3. Motor Operation Unstable (Speed Fluctuating)	Start compensation set too high
	Slip Compensation set too high
	Improper current feedback
	PID Regulator or Auxiliary Reference mis-adjusted
	Control signal noise
4. Motor Draws High Current But Cannot Start. (May appear to rock back and forth.)	Start voltage set too high
	Open winding in motor
	Open connection to motor
	One inverter phase missing. Test output phase balance.

SYMPTOM/CAUSE CHARTS

SYMPTOM	POSSIBLE CAUSES
5. Motor Runs Unloaded But Stalls When Loaded. (Motor may run rough and VLT may trip.)	Current Limit set too low One half of one inverter phase missing. Test output phase balance.
6. Unbalanced Input Phase Currents *Note: Slight variations in phase currents are normal. Variations greater than 5% require investigation.*	Input line voltage unbalanced Faulty connection on input wiring Fault in plant power transformer Input Rectifier module faulty (open diode).
7. Unbalanced Motor Phase Currents *Note: Slight variations in phase currents are normal. Variations greater than 5% require investigation.*	Open motor winding Faulty motor connection Fault in inverter section (see Symptom No. 6.)

STATIC TEST PROCEDURES

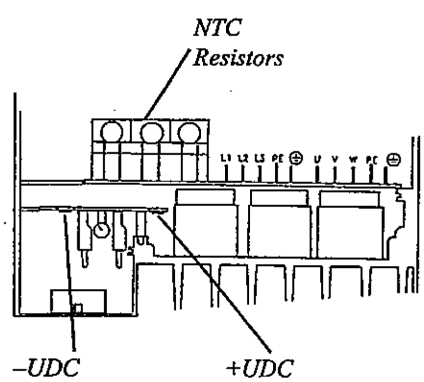
All tests will be made with a meter capable of testing diodes. Use a digital VOM set on diode scale or an analog ohmmeter set on R x 100 scale. Before making any checks disconnect all input power, motor and brake option connections.

CAUTION:

Allow sufficient time for the DC Bus to fully discharge before beginning testing. The presence of bus voltage can be tested by setting your voltmeter for 1000VDC and reading the voltage at the labeled terminals shown in the drawings.

TESTING THE INPUT RECTIFIER

The purpose of making static tests on the input rectifier is to rule out failures in this device, either shorted or open diodes. Failure of the rectifier module will usually result in blown line fuses. It should be noted that blown input line fuses can also be the result of shorts in the IGBT module(s) or a damaged bus capacitor. See Testing the Inverter Section and Testing the Bus Capacitors. For measurements where an open-circuit is expected the meter may show some initial continuity as the DC Bus capacitors charge up. This is normal and to be expected.



VLT 3002-3004, 230V **VLT 3502-3504, 230V**
VLT 3002-3008, 380V/460V **VLT 3502-3511, 380V/460V**

1. Remove the Control Card to expose the ILD Card. Locate the UDC connector on the ILD Card (MK102). The red lead at the top side of the connector will be used for the (+UDC) test point and the black lead at the bottom of the connector will be the (–UDC) test point. The +UDC and –UDC fast-on terminals on the DC Card (as shown) can also be used.
2. Connect the positive (+) meter lead to (+UDC). Connect the negative (–) meter lead to terminals 91 (L1), 92 (L2), and 93 (L3) in turn. Each reading should be open.
3. Reverse the meter leads connecting the negative (–) meter lead to (+UDC) and the positive (+) meter lead to power terminals 91 (L1), 92 (L2), and 93 (L3) in turn. Each reading should show a diode drop.
4. Connect the positive (+) meter lead to the red lead (–UDC). Connect the negative (–) meter lead to power terminals 91 (L1), 92 (L2), and 93 (L3) in turn. Each reading should show a diode drop.
5. Reverse the meter leads connecting the negative (–) meter lead to the (–UDC) and the (+) meter lead to power terminals 91 (L1), 92 (L2), and 93 (L3) in turn. Each reading should show open. Test is complete.

Incorrect readings could indicate a faulty Rectifier Module. See Removal and Replacement Instructions. If there is an open circuit reading when a diode drop reading is expected, see Testing the Soft Charge Circuit.

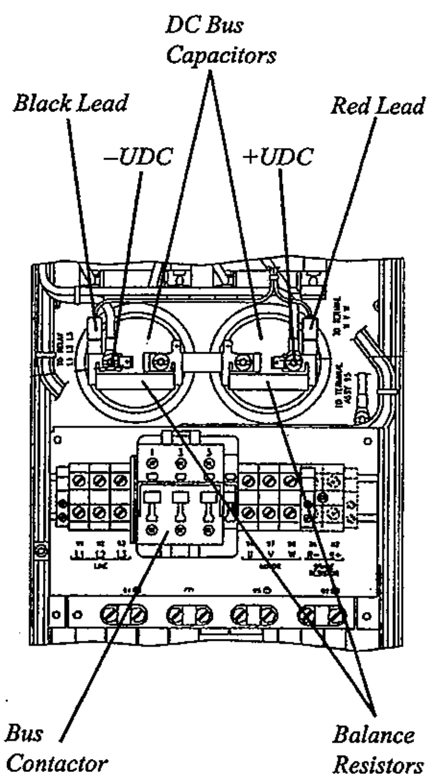
STATIC TEST PROCEDURES

TESTING THE INPUT RECTIFIER

VLT 3006-3022, 230V **VLT 3508-3532, 230V**
VLT 3011-3052, 380V/460V **VLT 3516-3562, 380V/460V**

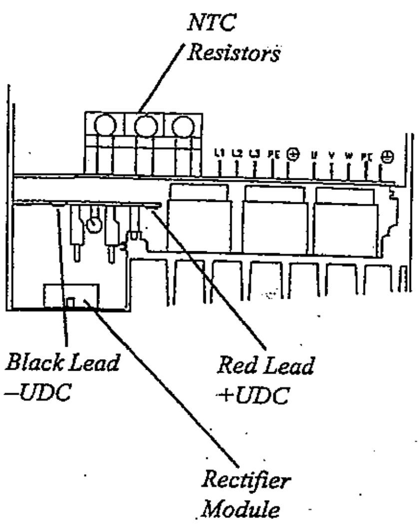
1. Remove any plastic shields covering the DC Bus Capacitors and locate the 18 gauge red and black leads connected to the Bus Capacitor bus bars as shown. These leads indicate the positive (+UDC) and negative (- UDC) DC Bus test points. The number and location of the bus capacitors will vary between units.
2. Connect the positive (+) meter lead to (+UDC). Connect the negative (-) meter lead in turn to the terminals (1/L1), (3/L2), and (5/L3) as labeled on the top side of the Bus Contactor. Each reading should be open.
3. Reverse the meter leads connecting the negative (-) meter lead to (+UDC) and the positive (+) meter lead in turn to the terminals (1/L1), (3/L2), and (5/L3) on the top side of the Bus Contactor. Each reading should read a diode drop.
4. Connect the positive (+) meter lead to (-UDC). Connect the negative (-) meter lead in turn to the terminals (1/L1), (3/L2), and (5/L3) on the top side of the Bus Contactor. Each reading should show a diode drop.
5. Reverse the meter leads connecting the negative (-) meter lead to (-UDC) and the positive (+) meter lead in turn to the terminals (1/L1), (3/L2), and (5/L3) on the top side of the Bus Contactor. Each reading should show open. Test completed.

Incorrect readings indicate a faulty rectifier module. See Removal and Replacement Instructions on page 4-4 If the rectifier module is shorted, it is important to inspect the Bus Charge Contactor. See page 3-3 for testing the soft-charge circuit.



STATIC TEST PROCEDURES

TESTING THE SOFT-CHARGE CIRCUIT



The purpose of the soft-charge circuit is to provide an initial high impedance current path for building up a charge on the Bus Capacitors. The size of the unit determines whether NTC resistors or PTC/Contactor combination are used.

VLT 3002-3004, 230V **VLT 3502-3504, 230V**
VLT 3002-3008, 380V/460V **VLT 3502-3511, 380V/460V**

Measure the three NTC resistors (R303, R304, R305) located on the ILD Card. The resistance should read about 10Ω - 20Ω at room temperature.

VLT 3006-3022, 230V **VLT 3508-3532, 230V**
VLT 3011-3052, 380V/460V **VLT 3516-3562, 380V/460V**

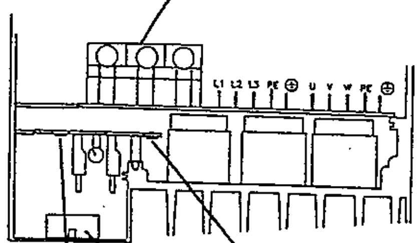
1. Inspect the Bus Charge Contactor. Remove the MK6 harness from the Relay Card (see Appendix for component location) and check that the contacts measure open and the spring mechanism is functional. The armature resistance should be approximately 500Ω.
2. Check the resistance of the PTC resistors located on the Relay Card. At room temperature the resistance value should be about 30Ω.
3. Remove the Balance Resistors from the DC Bus capacitors. Use an ohmmeter to insure that the resistance values are correct, (18KΩ).
4. If all measurements are correct, re-install all components and proceed with dynamic tests.

Incorrect readings could indicate a damaged Bus Contactor, Relay Card, or problems with the DC Bus capacitors. If a balance resistor is damaged, replace the bus capacitors the resistor mounted across as well as any series connected Bus Capacitors. See Replacing the Bus Contactor, replacing the Relay Card, and replacing the Bus Capacitors, page 4-4.

STATIC TEST PROCEDURES

TESTING THE INVERTER SECTION

The purpose of static testing the inverter section is to rule out failures in the IGBT power devices. If a short circuit is discovered during the testing, the particular module can be pinpointed by noting the output terminal indicating the short circuit. When looking in units with multiple IGBT modules, the "U" phase is on the left, "V" phase in the middle and the "W" phase is on the right.



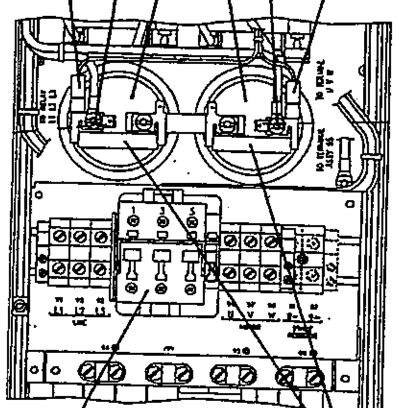
VLT 3002-3004, 230V
VLT 3002-3008, 380V/460V
VLT 3502-3504, 230V
VLT 3502-3511, 380V/460V

1. Disconnect the motor leads from the unit. The low winding resistance within the motor will affect test measurements in the inverter section.
2. Remove the Control Card to expose the ILD Card. Locate the UDC connector on the ILD Card (MK102). The red lead at the top side of the connector will be used for the (+UDC) test point and the black lead at the bottom of the connector will be the (–UDC) test point. The +UDC and –UDC fast-on terminals on the DC Card (as shown) can also be used.
3. Connect the positive (+) meter lead to terminal (+UDC). Connect the negative (–) meter lead to motor terminals 96 (U), 97 (V), and 98 (W) in turn. Each reading should be open.
4. Reverse the meter leads connecting the negative (–) meter lead to (+UDC) and the positive (+) meter lead to motor terminals 96 (U), 97 (V), and 98 (W) in turn. Each reading should show a diode drop.
5. Connect the positive (+) meter lead to (–UDC). Connect the negative (–) meter lead to motor terminals 96 (U), 97 (V), and 98 (W) in turn. Each reading should show a diode drop.
6. Reverse the meter leads connecting the negative (–) meter lead to (–UDC) and the positive (+) meter lead to motor terminals 96 (U), 97 (V), and 98 (W) in turn. Each reading should show open. Test is complete.

Incorrect readings indicate a damaged IGBT module. See Removal and Replacement Instructions on page 4-3.

STATIC TEST PROCEDURES

TESTING THE INVERTER SECTION



VLT 3006-3022, 230V **VLT 3508-3532, 230V**
VLT 3011-3052, 380V/460V **VLT 3516-3562, 380V/460V**

1. Prior to making any measurements it is necessary to disconnect the motor leads from the unit. The low winding resistance within the motor will make it appear that there is a short circuit in the inverter section.
2. Remove any plastic shields covering the DC Bus capacitors and locate the 18 gauge red and black leads connected to the capacitor bus bars. These leads indicate the positive (+UDC) and negative (-UDC) DC Bus test points as shown.
3. Connect the positive (+) meter lead to the red lead to (+UDC). Connect the negative (-) meter lead in turn to motor terminals (T1/U), (T2/V) and (T3/W). Each reading should be open.
4. Reverse the meter leads connecting the negative (-) meter lead to (+UDC) and the positive (+) meter lead in turn to motor terminals (T1/U), (T2/V), and (T3/W). Each reading should show a diode drop.
5. Connect the positive (+) meter lead to (-UDC). Connect the negative (-) meter lead in turn to motor terminals (T1/U), (T2/V), and (T3/W). Each reading should shoe a diode drop.
6. Reverse the meter leads connecting the negative (-) meter lead to (-UDC) and the positive (+) meter lead in turn to motor terminals (T1/U), (T2/V), and (T3/W). Each reading should show open. Test completed.

Incorrect readings indicate a damaged IGBT module. See Removal and Replacement Instructions on page 4-4.

STATIC TEST PROCEDURES

TESTING THE HEATSINK THERMAL SWITCH

There are thermal switches included on all units covered by this manual. The smaller drives monitor the ambient temperature within the unit. The thermal switch is mounted on the ILD Card. All units with Interface Cards have a stand alone thermal switch mounted on the heatsink.

VLT 3006-3022, 230V **VLT 3508-3532, 230V**
VLT 3011-3052, 380V/460V **VLT 3516-3562, 380V/460V**

The heatsink temperature is sensed by a thermal switch. The thermal switch harness is connected to the top of the Interface Card at connector MK401. The switch will open when the heatsink temperature exceeds 100°C/212°F and will close when the heatsink temperature falls below 50°C/122°F. By unplugging the connector from the Interface Card, the thermal switch continuity can be checked.

DYNAMIC TEST PROCEDURES

TESTING FOR OUTPUT PHASE VOLTAGE IMBALANCE

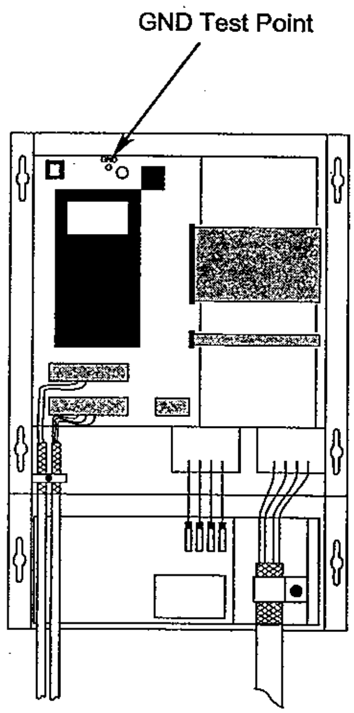
When testing phase imbalances, it is practical to measure both voltage and current. A balanced voltage reading, but unbalanced current, indicates the motor is drawing uneven current. This could be caused by a fault in the motor windings or in the wiring connections between the drive and motor. When both voltage and current are unbalanced, it indicates a switching problem or a faulty connection within the unit itself. This can be caused by improper gate drive signals as a result of a faulty interface board. A faulty IGBT or loose wire connection between the IGBT and the output terminals may also be the cause.

NOTE: When monitoring output voltage an analog voltmeter should be used. Digital meters are sensitive to the switching frequency and usually read erroneously.

1. Remove the motor leads from the output terminals of the unit.
2. Conduct the Inverter Test Procedure in Section Three.
3. If the Inverter Test Procedure proves good, power the unit back up. Initiate a Run command with a speed reference greater than 40Hz.
4. Read the phase-to-phase output voltage. The actual value of the readings is of less importance than the phase-to-phase balance. This balance should be within 8 volts per phase.
5. If a greater-than-8-volt imbalance exists, measure the gate drive firing signals.
6. If the phase-to-phase output voltage is balanced, recheck motor and connections for faults. Consult the factory for additional assistance.

DYNAMIC TEST PROCEDURES

TESTING FOR CURRENT FEEDBACK



A current sensor is in line with each phase of the output. These hall effect devices generate a current that is proportional to the current being drawn in each respective motor phase. The VLT relies on this feedback for proper output waveform control and for providing fault protection. Problems with the current sensors can cause unstable operation, over current trips, and ground fault trips.

A simple test of these signals can be made with a voltmeter. The measured voltage will be proportional to the current signal produced by each current sensor. At very light loads the AC voltage signal may be no more than 100mV to 300mV. The purpose of this test is to verify that all three sensors are functioning and that the signals are approximately equal when compared to each other.

1. Apply power to the unit. Leave the unit in stop mode.
2. Using a DC voltmeter, connect the negative (–) meter lead to the Control Card test point labeled GND. Connect the positive (+) meter lead in turn to pins 4, 5, and 6 of the Control Card MK200 connector, (pin 1 of MK200 is on the lower side, closest to the MK201 connector). All three readings should be within 20 millivolts of zero.
3. Start the drive and bring the motor up to stable speed. Change the voltmeter to read AC voltage and measure the Same signals at pins 4, 5, and 6 of MK201. All readings should be approximately equal.

Severe imbalances in the readings indicate a faulty current sensor or an uneven current draw by the motor. See "Testing for Output Phase Voltage Imbalance" on page 3-6. (The current sensors will vary with unit size. Consult Appendix drawings for assistance in finding component locations.)

Control Card Ribbon Cables

Connector	Pin	Signal	Function
MK200	20	+5V	
	19	+5V	
	18	+5V	
	17	+5V	
	16	INVOK	FAULT LOGIC
	15	WP	PWM SIGNALS
	14	VP	
	13	UP	
	12	SYNC	SERIAL COMMUNICATION SIGNAL
	11	DISAB	RUN MODE LOGIC
	10	COM	COMMON FOR +13V, –13V, +5V SAME AS "GND" TEST POINT
	9	COM	
	8	COM	
	7	SIN	NOT USED
	6	CR BW	MOTOR CURRENT SIGNALS
	5	CR BV	
	4	CR BU	
	3	VF B	DC BUS SIGNAL
	2	+13V	
	1	–13V	
MK201	2	+24V	SEPERATE CONTROL LOGIC POWER SUPPLY
	1	COM1	

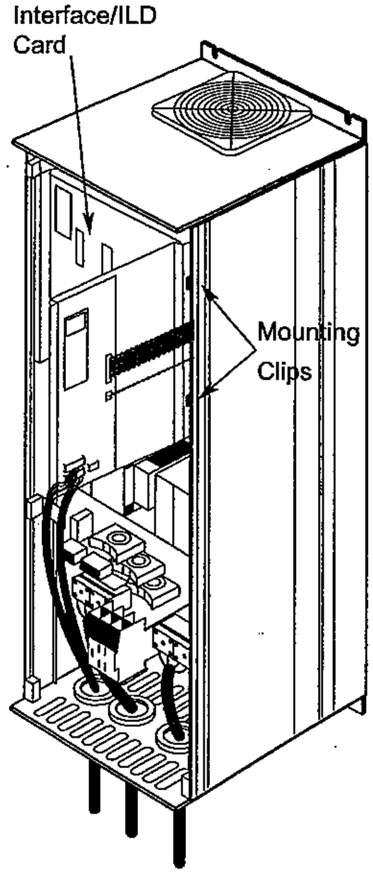
TESTING GATE DRIVE FIRING CIRCUITS

CAUTION: The gate firing signals are referenced to the negative DC Bus and are therefore at Bus potential. Extreme care must be taken to prevent personal injury or damage to equipment. Oscilloscopes, when used, should be equipped with isolation devices.

The individual gate drive firing pulses originate on the Interface/ILD Card. These signals are then distributed to the individual IGBT's. An oscilloscope is the instrument of choice when observing waveforms; however, when a scope is not available, a simple test can be made with a DC voltmeter. When using a voltmeter, compare the gate pulse voltage readings between phases. A missing gate pulse or an incorrect gate pulse have a different average voltage when compared with the other pulse outputs. At very low frequencies (below 10Hz) the voltmeter reading will tend to bounce around as the pulses rise and fall. Above 10Hz the reading will stabilize. When using an oscilloscope, the test points remain the same, as shown. These tests must be made with the motor disconnected. The internal impedance of a meter or scope can induce problems to the IGBTs.

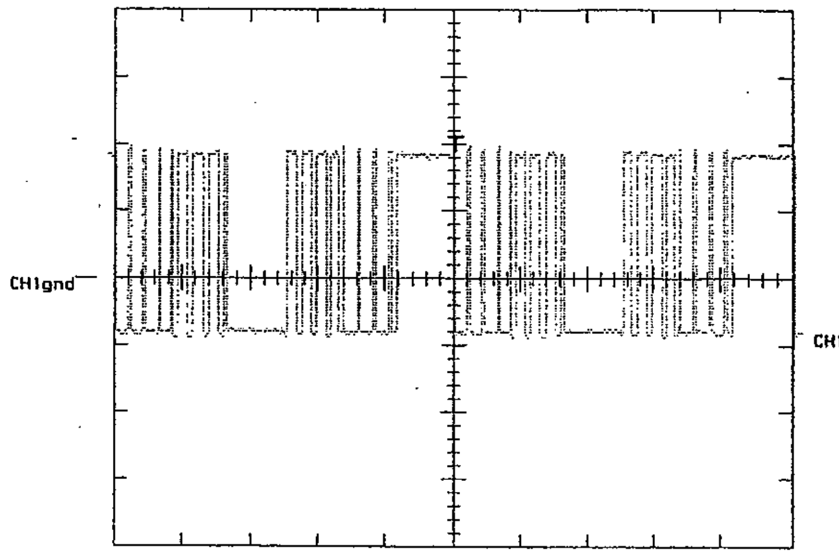
1. With power off, remove and re-install the Control Card as shown to allow easy access to the Interface/ILD Card.*
2. Measure the resistance at each of the six test points. Each test point should read approximately 2.2kΩ.
3. Apply power and run the unit up to 20Hz. Measure each of the six IGBT gate pulse signals.
4. If gate pulses are missing or the readings are inconsistent, remove power, remove the three IGBT gate wire harnesses from the Interface/ILD Card and measure the gate pulse signals directly at the Interface/ILD Card Connectors.

There may be a slight DC shift in voltage readings between the positive and negative half IGBT gate signals.



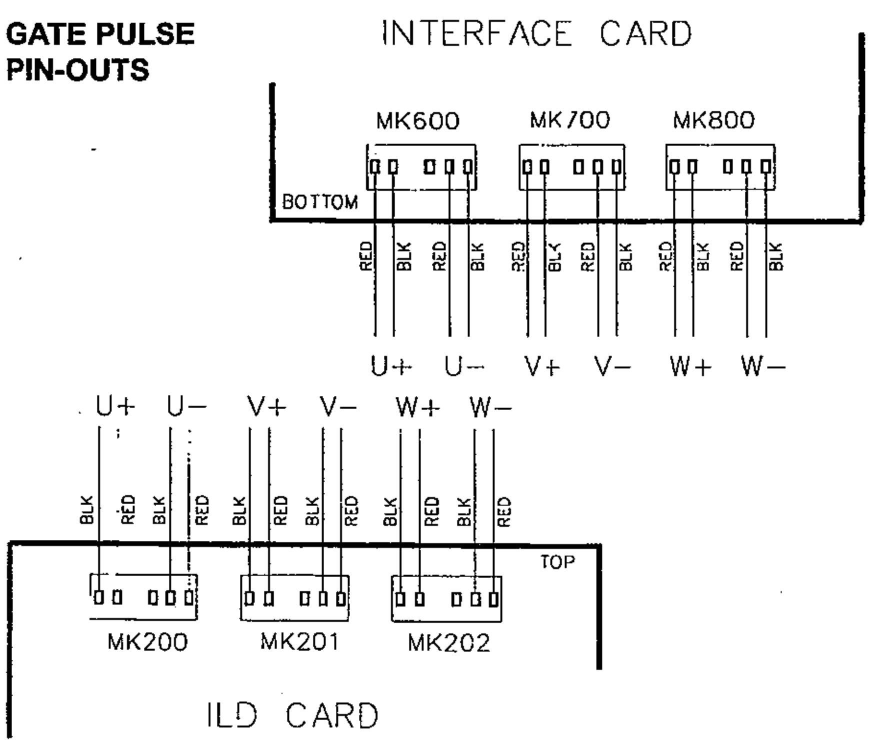
To Expose the Interface/ILD Card:

- Leaving the Ribbon Cables attached, remove the Control Card
- Mount the card by snapping the right side (edge) of the Control Card into the two (2) mounting clips.



Gate pulses @ 20Hz, 10V/Div, 10mS/Div

GATE PULSE PIN-OUTS



TESTING INPUT RECTIFIERS

Theoretically, the input current drawn on each of the three input phases should be equal. These currents will vary, however, due to variations in phase-to-phase input voltage and due to some single phase loads within the drive.

Given that the input phase voltages are equal, the input currents phase-to-phase should not vary more than 5%. Current imbalances in excess of 5% may indicate one of the diodes is not conducting properly. When the VLT is lightly loaded, it may not be possible to detect a current imbalance. If suspect, the modules should be statically tested. Refer to the Static Test procedures beginning on page 3-1.

COMPONENT REPLACEMENT PROCEDURES

REMOVING & REPLACING THE CONTROL CARD

NOTE: The Control Card comes mounted to a metal plate. When installed this plate sits in a slot provided on the left-hand side of the unit enclosure and is secured by two press-fit mounting clips attached to the right-hand side of the enclosure.

These mounting clips provide the earth ground connection for the Control Card. If loose or damaged, the Control Card may experience electrical noise problems resulting in an "Except Fault" (see page 2-4).

REMOVAL

- Remove the two ribbon cables from plugs MK200 and MK201.
- Insert a screwdriver at the points indicated on the right side of the control card plate and pry upward.
- Lift the control card plate out and set aside.

REPLACEMENT

- Inspect Control Card mounting clips to ensure they are not loose or damaged.
- Insert the left side of the control card plate into the slot on the left side of the enclosure and slide the card down against the metal stop to ensure proper alignment with front cover.
- Reconnect the two ribbon cables to plugs MK200 and MK201.
- Firmly press down on the right side of the control card plate until it snaps into place.

REMOVING & REPLACING THE ILD CARD, DC CARD, RECTIFIER CARD AND IGBT

VLT 3002-3004, 230V
VLT 3002-3008, 380V/460V

VLT 3502-3504, 230V
VLT 3502-3511, 380V/460V

ILD Card:

1. Remove the ground screw(s) on the ILD Card. The screws are located at the bottom and possibly at the top right on the board.
2. Remove all wire harnesses from the ILD Card. The three leads connecting the ILD Card to the motor coils may need to be removed from the Motor Coil side. The replacement ILD Card will show if these leads should be disconnected from the ILD Card or from the Motor Coils. Pay close attention to the orientation and routing of these wire leads.
3. Use the tip of a flat-head screw driver to release the ILD Card from the plastic mounting clips and lift the card upward.
4. To install, make sure that the Insulation Foil is in place.
5. Connect the ILD Card to Motor Coil wire leads.
6. Reverse the rest of the installation steps.

DC Card:

1. Remove the wires connecting the DC Card to the Bus Coil and the IGBTs.
2. Remove the mounting screws and the green/yellow ground lead.
3. Use the tip of a flat-head screw driver to release the DC Card from the plastic mounting clips and lift the card upward. This may require a little flexing of the side of the enclosure to accomplish.
4. Remove the wires connecting the DC Card to the rectifier module and remove the DC Card.
5. Reverse the steps above to replace.

Rectifier Module:

1. Remove the wire harness from the module terminals. Note the wire orientations.
2. Remove the two mounting screws and remove the module.
3. Clean the thermal grease from the enclosure heatsink and from underneath the Rectifier Module.
4. Install the wire harness to the module.
5. Apply silicon grease 3 mils thick to the entire base of the Rectifier Module.
6. Secure the Rectifier with the two screws. Torque to 12-14 LB-IN (1.5Nm).

Six-Pack IGBT Module:

1. Remove all wire leads connected to the Six-Pack module.
2. Remove the mounting hardware and remove from the unit.
3. Clean the remaining heatsink compound from the enclosure heatsink and the Six-Pack module.
4. Apply silicon grease 3 mils thick to the entire base of the Six-Pack module.
5. Install the module and alternately tighten the mounting hardware to 21-23 LB-IN (2.5Nm).
6. Re-connect all wire leads to the Six-Pack Module.

IGBT Modules (VLT 3008, 380V/460V; VLT 3508-3511, 380/460V):

1. Remove all wire leads connected to the IGBT modules.
2. Remove the hardware holding the DC Link PCB to the IGBT Modules.
3. Remove the hardware which connects the Motor Coil to the IGBT lead on the module to be replaced.
4. Remove the two mounting screws and remove from the unit.
5. Clean the heatsink grease from the enclosure heatsink and underneath the IGBT Module.
6. Apply silicon grease 3 mils thick to the entire base of the IGBT Module.
7. Install the module and tighten the mounting hardware to 21-23 LB-IN (2.5Nm).
8. Reverse the steps above to replace.

REMOVING & REPLACING THE INTERFACE CARD, RELAY CARD, RECTIFIER, AND IGBT

VLT 3006-3022, 230V **VLT 3508-3532, 230V**
VLT 3011-3052, 380V/460V **VLT 3516-3562, 380V/460V**

To gain access to some assemblies remove the Control Card (page 4-2). It may also be necessary to remove one of the enclosure cross support braces to gain access to components on some units.

Interface Card:

1. Remove all wire harnesses from the Interface Card.
2. Remove the ground screw from the top right-hand corner, (on units without Interface Card ground wire).
3. Note in which enclosure slot the left side of the interface card was mounted. Use the tip of a flat-head screw driver to release the right side of the Interface Card from the plastic board supports and lift the board out of the unit.
4. Remove and inspect the Interface Card Insulation Foil, (not on 230V units).
5. Replace the Insulation Foil.
6. Slide the left-hand side of the Interface Card in the appropriate enclosure slot and snap the right-hand side of the plastic board supports. Make sure that all wire harnesses are accessible prior to seating the Interface Card.
7. Re-connect all wire harnesses and the ground screw.

Relay Card:

1. Remove all wire harnesses from the Relay Card.
2. Release the Relay Card from all plastic mounting clips and remove. Use the tip of a flat-head screw driver for the black plastic clips and needle nose pliers if white plastic stand-offs are used.
3. For units with the current sensors mounted on the Relay Card, note the wire labeling and orientation prior to moving the board. Remove the three leads connected to the drive side of the motor terminal strip and feed the leads back through the current sensors.
4. Reverse the steps above to replace.

Rectifier Module:

1. Remove the five terminal screws from the module. Note the wire orientation and disconnect all wire leads.
2. Remove the two mounting screws securing the rectifier module to the heatsink and remove the module.
3. Clean the thermal grease from the enclosure heatsink and from underneath the Rectifier Module.
4. Apply silicon grease 3 mils thick to the entire base of the Rectifier Module.
5. Install the module and alternately torque the screws to 19-21 LB-IN (2.2Nm).
6. Replace all wire leads to the Rectifier Module terminals and torque the terminal hardware to 19-21 LB-IN (2.2 Nm).

IGBT Module:

1. Remove the HF Card (does not apply to 230V units).
2. Remove all hardware mounting the IGBT bus bars and the Clamp Capacitors.
3. Remove the remaining wire connecting the IGBT to the Motor Coil.
4. Remove the mounting screws on the IGBT and remove from the unit.
5. Clean the thermal grease from the enclosure heatsink and from underneath the IGBT Module.
6. Prior to installing the IGBT module, apply silicon grease 3 mils thick to the entire base of the module.
7. Install the module and lightly tighten the mounting screws. Tighten the mounting screws to a final torque of 19-21 LB-IN (2.2Nm).
8. Re-install the IGBT bus bars, clamp capacitors and Motor Coil lead. The IGBT terminal hardware (including the 7mm HF Card standoffs) should be torqued to 27-29 LB-IN, (3.2 Nm).
9. Replace the HF Card and HF Card foil. The HF Card mounting screws should be tighten down to 12-14 LB-IN, (1.5Nm)

APPLICATIONS

CURRENT LIMIT TRIPS

UNSTABLE MOTOR OPERATION

Excessive loading of the VLT may result in "CURRENT LIMIT" trips. This is not a concern if the unit has been properly sized and intermittent load conditions cause anticipated operation in current limit. Nuisance current limiting and unstable motor operation can, however, be caused by improperly setting specific parameters. The following parameters are those which are most critical to the VLT/Motor relationship.

100 - Load Type

103 - Motor Power

104 - Motor Voltage

105 - Motor Frequency

107 - Motor Current

108 - Motor Magnetizing Current

109 - Start Voltage

110 - Start Compensation (VLT 3000 only)

209 - Current Limit

PARAMETER 100
Load type is selected based on application demands. VLT Series 3000 drive can be set for both constant and variable torque applications. The VLT Series 3500 drive is specifically designed for variable torque applications. The available selections vary between these different series. An incorrect setting may provide an improper voltage to frequency (V/F) ratio to the motor with respect to load demand. For example, a constant torque (CT) load requires a higher V/F ratio at start-up than a variable torque (VT) load. If a VT mode of operation has been selected for a CT load, sufficient starting torque will not be available.

When a VLT Series 3000 unit is set for one of the variable torque modes, adjustments to parameters 109-113 will have no effect. The various VT modes have direct control over these parameters. When one of the CT Start/VT modes is selected on a VLT Series 3000 unit, the above mentioned parameters will have effect only until the reference has been reached. At this point the unit reverts to VT operation. It should be noted that parameters 110-113 do not exist in the VLT Series 3500.

PARAMETERS 103, 104, 105, 107
These parameters, when incorrectly set, have an effect on other parameters as well as the unit's interpretation of the load. In setting these parameters enter the name plate data from the motor into the appropriate parameter. Use the conversion chart to change from HP to KW.

HP	1	2	3	5	7	10	15	20	30	40	50	60	75
kW	0.75	1.5	2.2	4.0	5.5	7.5	11	15	22	30	37	45	55
HP	100	125	150	200	250	300							
kW	75	90	110	160	185	200							

PARAMETER 108
Motor Magnetization Current is the current required to maintain the magnetic field in the motor. Magnetization Current is factory set based on the motor power entered in parameter 103. This current value can also be found by running the motor without anything connected to the shaft and recording the current. Data charts in motor catalogs also contain this information.

PARAMETER 109
Start voltage is factory set based on the motor power entered in parameter 103. In most cases the factory setting is sufficient; however, a slight increase in start voltage may be required for high inertia loads. High current at low speeds results in an increased voltage drop in the motor and hence the need for additional start voltage.

If multiple motors are connected to a single unit, it is usually necessary to increase the start voltage. Smaller motors have greater voltage drops at low frequencies so additional start voltage is usually required.

It is also possible to have start voltage set too high and result in start-up trouble. The best rule of thumb is to start at the factory setting and make changes in small increments. Start and stop the unit to test the results.

PARAMETER 110 (VLT SERIES 3000 ONLY)
Start compensation is factory set based on the motor power entered in Parameter 103. In most cases the factory setting is sufficient, however, a slight increase in start compensation may be necessary with loads requiring high starting torques and loads with changing demands as speed increases.

If multiple motors are connected to a single unit, the start compensation must be set to zero.

It is also possible to have start compensation set too high, resulting in excessive current drawn at start up and motor instability.

PARAMETER 209
Current limit is factory set based on the motor size and voltage selected. Current limit settings which are too low may result in difficulty starting or premature trips.

Current limit will automatically reset to 160% of the value entered into parameter 107 unless this would exceed the maximum allowable value.

"GROUND FAULT" TRIPS

Trips occurring from ground faults are usually the result of short circuits to earth ground either in the motor or the wiring to the motor. The VLT detects ground faults by monitoring all three phases of output current and looking for severe imbalances in those currents. When a "Ground Fault" trip occurs it is necessary to measure the resistance of the motor windings and wiring with respect to earth ground. The instrument normally used for this purpose is a Megohmmeter or commonly referred to as a "Megger". Many times these resistance readings are taken with a common Ohmmeter, which is actually incapable of detecting any shorts other than those that are virtually direct. A Megger has the capability of supplying higher voltages, typically 500 volts or more, which enables the Megger to detect breakdowns in insulation or higher resistance shorts which cannot be picked up through the use of an Ohmmeter. When using a megger, it is necessary to disconnect the motor leads from the output of the VLT. The measurements should then be taken so that the motor and all associated wiring and connections are captured in the test. When reading the results of the Megger test, the rule of thumb is any reading less than 500 Megohms should be suspect. Solid, dry wiring connections normally result in a reading of infinity.

Since the VLT monitors output current to detect ground faults, there is also the possibility that the current sensors and/or the detection circuitry in the VLT could also be the cause of a ground fault. Tests can be made on this circuitry to isolate the possibilities. Refer to the Dynamic Test procedures on "Testing for Current Feedback" page 3-7. Consult the factory for additional assistance.

"OVERCURRENT" TRIPS

Trips due to "OVERCURRENT" can be caused by short circuits on the output of the unit or by instantaneous high currents occurring so rapidly that the unit's current limit cannot respond.

Short circuit trips are generally a result of a phase-to-phase short in the motor windings or in the wiring between the unit and the motor. Short circuit trips are easily diagnosed by removing the motor leads from the unit and performing a phase-to-phase resistance test on the motor leads. This resistance read in ohms will normally be quite low so it is important to have the ohmmeter set on its lowest resistance scale to avoid mis-interpreting the readings observed.

"OVERCURRENT" TRIPS

Instantaneous overcurrent trips are caused by the current rising so fast on the output that the unit cannot respond. One example of this situation is in applications where the unit is running at speed and an output contactor is closed between the unit and the motor. At the point the contactor is closed, the motor is effectively seen as a short circuit to the unit. During this time the unit will attempt to gain control of the motor by employing current limit. If the current limit function is unable to limit the current to acceptable levels, the result will be an "OVERCURRENT" trip. This example is not to imply that output contactors should not be used. In fact, that is quite the contrary as the VLT has been designed to withstand this type of operation without failure. The important consideration in applications such as this is that the unit is properly sized to handle the inrush currents.

A second example of instantaneous overcurrent is that experienced in applications with windmilling loads. A large fan has not yet been commanded to run; however, air movement is causing the fan to rotate. When the unit is started it must first drive the fan to zero speed and then begin the acceleration process from there. The amount of current required may be so great and rise so rapidly that the current limit function cannot control the process. The result is an "OVERCURRENT" trip. However, this situation can also be solved by a VLT feature, "Flying Start". With the flying start feature employed the VLT will interrogate the motor to determine its effective frequency and match the VLT output to that same frequency. Flying start results in a smooth start and full control of the load current.

"OVERVOLTAGE" TRIPS DUE TO REGENERATIVE APPLICATIONS

Regenerative energy is created when the load overhauls the motor. This means that the motor is being forced by the inertia of the load to rotate at a speed greater than the command speed. When overhauling occurs, the motor acts as a generator and the voltage generated is returned to the DC capacitor bank in the unit.

Regeneration is most commonly found in applications with high inertia loads and medium to fast decel ramps. However, even an unloaded motor ramped down fast enough can cause regeneration to occur.

It is most common that regeneration is experienced during ramping, although loads such as flywheels will generate regenerative energy to some degree on every cycle.

Since the unit can absorb approximately 15 percent of the motor's rated power in regenerated energy, this phenomena will go unnoticed in most applications.

"OVERVOLTAGE" TRIPS DUE TO REGENERATIVE APPLICATIONS

When the energy returned, combined with the DC Bus voltage, exceeds the upper voltage limit, the unit responds in different ways to limit the voltage rise. If the returned energy is occurring during ramp down (to stop or to a lower speed), the unit will automatically adjust the decel ramp in an attempt to limit the voltage. In more severe instances, the ramp may even stop for periods of time to allow the voltage to dissipate. During these periods while regeneration is occurring, the words "HIGH VOLTAGE" can be observed flashing in the control card display. If the returned energy is returned at a high enough level and/or so fast that the unit cannot respond, the unit will trip on "OVERVOLTAGE".

To prevent a trip from occurring, one solution is to lengthen the decel ramp. Another solution is to release the motor using the "Motor Coast" function. The "Flying Start" function is usually employed when using this method.

In very high inertia applications where a short decel time is required, the only solution may be that of adding a Dynamic Brake Option (only VLT Series 3000 units only).

The Dynamic Brake option combines a power IGBT, the electronics for controlling it and a resistor bank of sufficient wattage to dissipate the unwanted energy. The Dynamic Brake option monitors the level of the DC Bus voltage. When the voltage level exceeds permissible limits, the IGBT is switched on and the excess DC Bus voltage is dissipated in the resistor bank.

Particular attention must be paid to the proper sizing of the resistor bank. Consult your local representative or the factory for assistance in selecting the appropriate Dynamic Brake option and dynamic brake resistors for your application.

FAULT MEMORY

The VLT stores faults which have occurred in its fault memory register. The register stores the last 8 occurrences on a first in first out basis. You can access the fault memory by calling up parameter 602. In doing so you can then scroll through the register using the Data key to view each fault code stored. The codes that are displayed correspond to the numbers in parenthesis printed next to the Alarm Messages described on page 2-3.

In addition there are six more codes which may appear in parameter 602.

10) Trip Locked
Indicates a trip lock fault has occurred.

11) CT/OP Card Fault
Indicates a software fault has occurred in either the Control Card or an installed option card.

12) Ref Flt Timeout
Indicates the Reference Fault Timeout has occurred as controlled by Parameters 414 and 415.

13) Adaptive Tune Fail
Indicates the Adaptive Tuning Process failed, initiated by parameter 106.

14) DC Supply Fault
Indicates one or more of the low voltage DC power supplies have fallen out of tolerance.

15) Motor Thermistor
Indicates the motor thermistor as selected in parameter 400 has caused the trip.

SPARE PARTS

VLT 3002-3004, 230V
VLT 3502-3504, 230V

	VLT 3002 VLT 3502	VLT 3003	VLT 3004 VLT 3504
Control Card (VLT 3000)	175H7086	175H7086	175H7086
Control Card (VLT 3500)	175H4539	N/A	175H4539
ILD Card	175H7064	175H7065	175H7066
DC Bus Card	175H7018	175H7018	175H7019
Six Pack IGBT	175H7017	175H7017	175H7017
Recifier Module	612L2026	612L2026	612L2026
Brake Control Card *	175H7030	175H7030	175H7030
Brake IGBT *	175H7029	175H7029	175H7029
Top Fan IP54	175H0327	175H0327	175H0327
Insulator Foil	175H1415	175H1415	175H1415

* Only on VLT 3000

SPARE PARTS

VLT 3006-3022, 230V
VLT 3508-3532, 230V

	VLT 3006 VLT 3508	VLT 3008 VLT 3511	VLT 3011 VLT 3516	VLT 3016 VLT 3522	VLT 3022 VLT 3532
Control Card (VLT 3000)	175H7086	175H7086	175H7086	175H7086	175H7086
Control Card (VLT 3500)	175H4539	175H4539	175H4539	175H4539	175H4539
Interface Card	175H5375	175H5376	175H5377	175H5379	175H5382
IGBT Module	175H5340	175H5340	175H5341	175H5341	175H4510
IGBT Snubber Cap	175H0810	175H0810	175H0810	175H0831	175H0831
Recifier	612L9471	612L9471	612L9472	612L9473	612L9264
Relay Card	175H4481	175H4481	175H4481	175H4483	175H4485
Current Sensor	N/A	N/A	N/A	N/A	175H1789
Bus Charge Contactor	175H1761	175H1761	175H1761	175H1762	175H1762
Bus Contactor Coil Cap	175H2852	175H2852	175H2852	175H2852	175H2852
Time Delay Relay Module	047H0173	047H0173	047H0173	047H0173	047H0173
DC Cap Resistor	175H2324	175H2324	175H2324	175H2324	175H2324
DC Bus Capacitor	612B6762	612B6598	612B6708	612B6864	612B6864
Brake Control Card *	175H5398	175H5398	175H5398	175H5398	175H5398
Brake IGBT *	175H5370	175H5370	175H5370	175H5371	175H4508
MOV	175H7305	175H7305	175H7305	175H7305	175H7305
24V Internal Fan (IP54)	N/A	175H0827	175H0827	175H0827	175H0827
Top Fan (IP20)	24VDC 175H0827	24VDC 175H0827	24VDC 175H0827	230VAC 175H0761	230VAC 175H0761
Top Fan AC (IP54)	175H0753	175H0753	175H0761	175H0761	175H1807

* Only on VLT 3000

SPARE PARTS

VLT 3002-3008, 380V
VLT 3502-3511, 380V

	VLT 3002 VLT 3502	VLT 3003	VLT 3004 VLT 3504 VLT 3505	VLT 3006 VLT 3508	VLT 3008 VLT 3511
Control Card (VLT 3000)	175H7086	175H7086	175H7086	175H7086	175H7086
Control Card (VLT 3500)	175H4539	175H4539	175H4539	175H4539	175H4539
ILD Card	175H7067	175H7068	175H7069	175H7088	175H7087
ILD Card (VLT 3504)			175H7077		
DC Card	175H7020	175H7020	175H7021	175H7022	175H7023
Six Pack IGBT	175H7017	175H7017	175H7017	175H7017	N/A
IGBT Module	N/A	N/A	N/A	N/A	175H7016
DC Link	N/A	N/A	N/A	N/A	175H1162
Recifier Module	612L2026	612L2026	612L2026	612L2026	612L2026
Brake Control Card *	175H7031	175H7031	175H7031	175H7031	175H7031
Brake IGBT *	175H7029	175H7029	175H7029	175H7029	175H7029
Top Fan IP54	175H0327	175H0327	175H0327	175H0327	175H0327

* Only on VLT 3000

SPARE PARTS

VLT 3011-3032, 380
VLT 3516-3542, 380

	VLT 3011 VLT 3516	VLT 3016 VLT 3522	VLT 3022 VLT 3532	VLT 3032 VLT 3542
Control Card (VLT 3000)	175H7086	175H7086	175H7086	175H7086
Control Card (VLT 3500)	175H4539	175H4539	175H4539	175H4539
Interface Card (VLT 3000)	175H5386	175H5387	175H5388	175H5389
Interface Card (VLT 3500)	175H5392	175H5393	175H5394	175H5395
IGBT (VLT 3500)	175H0266	175H0266	175H7005	175H7005
VLT 3000 IGBT	175H0266	175H0266	175H7005	175H0268
IGBT Snubber Cap	175H0810	175H0810	175H0810	175H0810
Recifier	612L9261	612L9261	612L9262	612L9263
Relay Card Pre-Series 7**	175H4712 175H1099	175H4712 175H1099	175H4712 175H1099	175H4713 175H1143
Bus Charge Contactor Pre-Series 7**	175H1761 175H0841	175H1761 175H0841	175H1761 175H0841	175H1762 175H0842
Bus Contactor Coil Cap	175H2852	175H2852	175H2852	175H2852
DC Capacitor	612B6762	612B6598	612B6708	612B6864
Brake Control Card *	175H1572	175H1572	175H1572	175H1572
Brake IGBT *	175H7059	175H7059	175H7059	175H7060
MOV	175H4204	175H4204	175H4204	175H4204
24V Internal Fan (IP54)	N/A	175H0827	175H0827	175H0827
Top Fan (IP20)	24VDC 175H0827	24VDC 175H0827	24VDC 175H0827	230VAC 175H0765
Top Fan (IP54) 400VAC	175H0668	175H0668	175H0668	175H0765
Fan Cap (IP20)				175H4487
Fan Cap (IP54)			175H4487	175H4487
HF Card (IP20)	175H7303	175H7303	175H7303	175H7303
HF Card (IP54)	175H7304	175H7304	175H7304	175H7304
DC Balance Resistor	175H2324	175H2324	175H2324	175H2324
Interface Insulator Foil	175H1786	175H1786	175H1786	175H1784

* Only on VLT 3000

** Series included in unit serial number
Example: 0000 07 G000, Series 7

SPARE PARTS

VLT 3042-3052, 380V
VLT 3552-3562, 380V

	VLT 3042 VLT 3552	VLT 3052 VLT 3562
Control Card (VLT 3000)	175H7086	175H7086
Control Card (VLT 3500)	175H4539	175H4539
Interface Card (VLT 3000)	175H5390	175H5391
Interface Card (VLT 3500)	175H5396	175H5397
IGBT Module	175H0268	175H4100
Snubber Cap	175H0831	175H0831
Recifier	612L9264	612L9264
Relay Card Pre-Series 7**	175H4714 175H1143	175H4714 175H1143
Current Transducer	175H1789	175H1789
Bus Charge Contactor Pre-Series 7**	175H1762 175H0842	175H1762 175H0842
Bus Contactor Coil Cap	175H2852	175H2852
DC Capacitor	612B6598	612B6708
Brake Control Card*	175H1572	175H1572
Brake IGBT*	175H7061	175H7061
MOV	175H4204	175H4204
24V Internal Fan (IP54)	175H0827	175H0827
Top Fan (IP20) 400VAC	175H0765	175H0765
Top Fan (IP54) 400VAC	175H0765	175H1808
Fan Cap (IP20)	175H4487	175H4487
Fan Cap (IP54)	175H4487	175H4487
HF Card (IP20)	175H7303	175H7303
HF Card (IP54)	175H7304	175H7304
DC Balance Resistor	175H2324	175H2324
Interface Insulator Foil	175H1784	175H1784

* Only on VLT 3000

** Series included in unit serial number
Example: 0000_07_G000, Series 7

SPARE PARTS

VLT 3002-3008, 460V
VLT 3502-3511, 460V

	VLT 3002 VLT 3502	VLT 3003	VLT 3004 VLT 3504	VLT 3006 VLT 3506	VLT 3008 VLT 3508 VLT 3511
Control Card (VLT 3000)	175H7086	175H7086	175H7086	175H7086	175H7086
Control Card (VLT 3500)	175H4539	175H4539	175H4539	175H4539	175H4539
ILD Card	175H7072	175H7073	175H7074	175H7075	175H7076
ILD Card (VLT 3511)					175H7054
DC Card	175H7024	175H7024	175H7025	175H7026	175H7026
Six Pack IGBT	175H7017	175H7017	175H7017	175H7017	N/A
IGBT Module	N/A	N/A	N/A	N/A	175H7016
DC Link	N/A	N/A	N/A	N/A	175H1162
Recifier Module	612L9351	612L9351	612L9351	612L9351	612L9351
Brake Control Card*	175H7031	175H7031	175H7031	175H7031	175H7031
Brake IGBT*	175H7029	175H7029	175H7029	175H7029	175H7029
Top Fan IP54	175H0327	175H0327	175H0327	175H0327	175H0327
Insulator Foil	175H1415	175H1415	175H1415	175H1415	175H1415

* Only on VLT 3000

SPARE PARTS

VLT 3011-3032, 460V
VLT 3516-3542, 460V

	VLT 3011 VLT 3516	VLT 3016 VLT 3522	VLT 3022 VLT 3532	VLT 3032 VLT 3542
Control Card (VLT 3000)	175H7086	175H7086	175H7086	175H7086
Control Card (VLT 3500)	175H4539	175H4539	175H4539	175H4539
Interface Card	175H5378	175H5380	175H5381	175H5383
IGBT Module	175H5342	175H5342	175H5343	175H6251
IGBT Snubber Cap	175H0810	175H0810	175H0810	175H0831
Recifier	612L9474	612L9474	612L9475	612L9476
Relay Card	175H4482	175H4482	175H4482	175H4484
Bus Charge Contactor	175H1761	175H1761	175H1761	175H1762
Bus Contactor Coil Cap	175H2852	175H2852	175H2852	175H2852
DC Capacitor	612B7095	612B7096	612B7098	612B7096
Brake Control Card *	175H5399	175H5399	175H5399	175H5399
Brake IGBT *	175H5372	175H5372	175H5372	175H5373
MOV	175H7306	175H7306	175H7306	175H7306
24V Internal Fan (IP54)	N/A	175H0827	175H0827	175H0827
Top Fan (IP20)	24VDC 175H0827	24VDC 175H0827	24VDC 175H0827	230VAC 175H0761
Top Fan (IP54)	460VAC 175H0754	460VAC 175H0754	230VAC 175H0761	230VAC 175H0761
Fan Start Cap (IP20)	N/A	N/A	N/A	175H7327
Fan Start Cap (IP54)	N/A	N/A	175H7327	175H7327
Fan Series Cap (IP20)	N/A	N/A	N/A	175H7328
Fan Series Cap (IP54)	N/A	N/A	175H7328	175H7328
HF Card (IP20)	175H7303	175H7303	175H7303	175H7303
HF Card (IP54)	175H7304	175H7304	175H7304	175H7304
DC Balance Resistor	175H2324	175H2324	175H2324	175H2324
Interface Insulator Foil	175H1785	175H1785	175H1785	175H1783

* Only on VLT 3000

SPARE PARTS

VLT 3042-3052, 460V
VLT 3552-3562, 460V

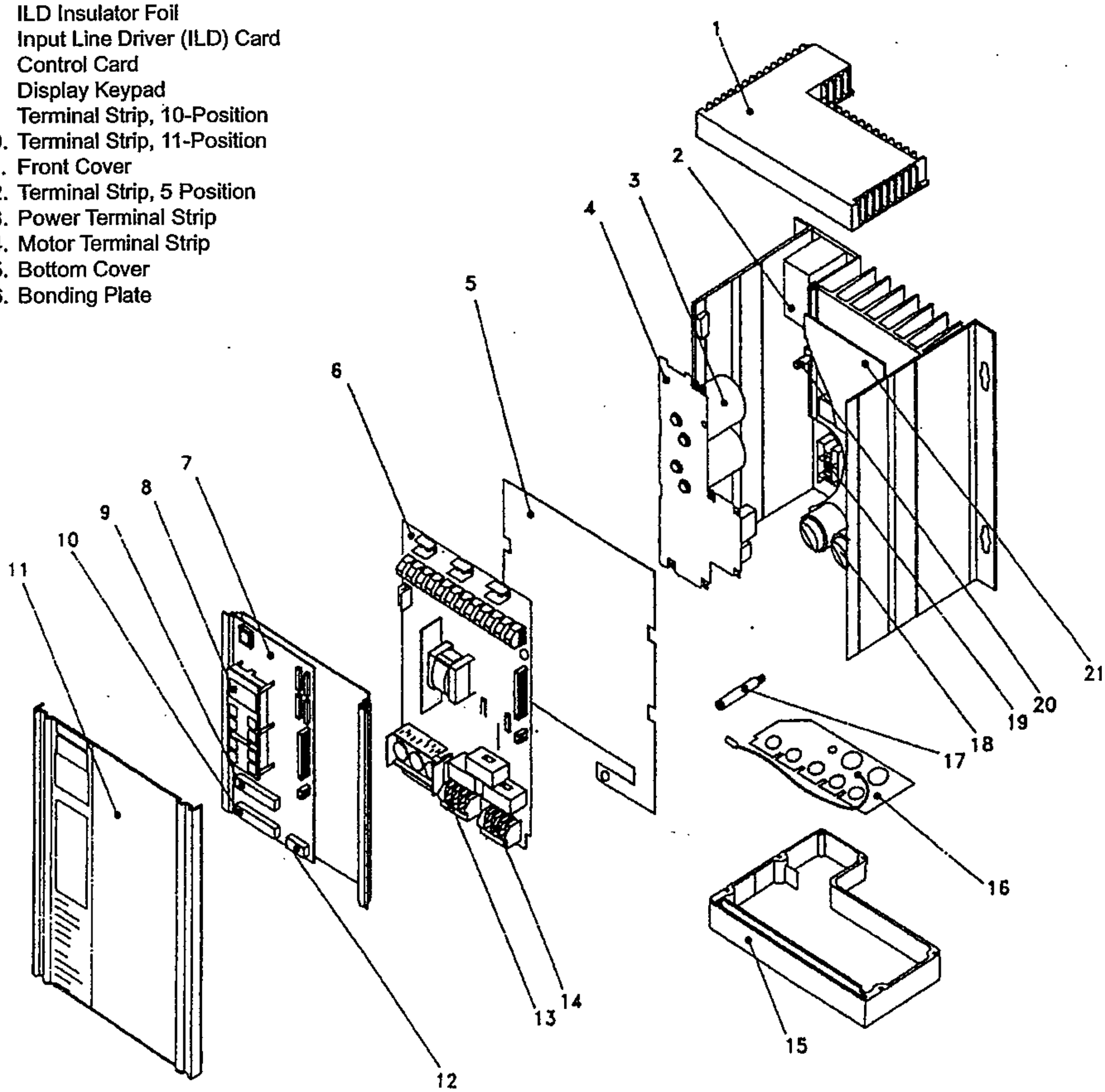
	VLT 3042 VLT 3552	VLT 3052 VLT 3562
Control Card (VLT 3000)	175H7086	175H7086
Control Card (VLT 3500)	175H4539	175H4539
Interface Card	175H5384	175H5385
IGBT Module	175H6251	175H1371
IGBT Snubber Cap	175H0831	175H0831
Recifier	612L9476	612L9477
Relay Card	175H4486	175H4486
Bus Charge Contactor	175H1762	175H1762
Bus Contactor Coil Cap	175H2852	175H2852
DC Capacitor	612B7097	612B7097
Brake Control Card*	175H5399	175H5399
Brake IGBT*	175H4509	175H4509
MOV	175H7306	175H7306
24V Internal Fan (IP54)	175H0827	175H0827
Top Fan (IP20) 230VAC	175H0761	175H0761
Top Fan (IP54) 230VAC	175H1807	175H1807
Fan Cap (IP20)	175H4487	175H4487
Fan Cap (IP54)	175H4487	175H4487
Fan Start Cap (IP20)	175H7327	175H7327
Fan Start Cap (IP54)	175H7328	175H7328
Fan Series Cap (IP20)	175H7328	175H7328
Fan Series Cap (IP54)	175H1855	175H1855
HF Card (IP20)	175H7303	175H7303
HF Card (IP54)	175H7304	175H7304
DC Balance Resistor	175H2324	175H2324
Current Transducer	175H1789	175H1789
Interface Insulator Foil	175H1783	175H1783

* Only on VLT 3000

COMPONENT LOCATION

VLT 3002-3004, 230V **VLT 3502-3504, 230V**
VLT 3002-3008, 380/460V **VLT 3502-3511, 380/460V**

1. Top Cover
2. DC Coil
3. DC Bus Capacitor
4. DC Card
5. ILD Insulator Foil
6. Input Line Driver (ILD) Card
7. Control Card
8. Display Keypad
9. Terminal Strip, 10-Position
10. Terminal Strip, 11-Position
11. Front Cover
12. Terminal Strip, 5 Position
13. Power Terminal Strip
14. Motor Terminal Strip
15. Bottom Cover
16. Bonding Plate

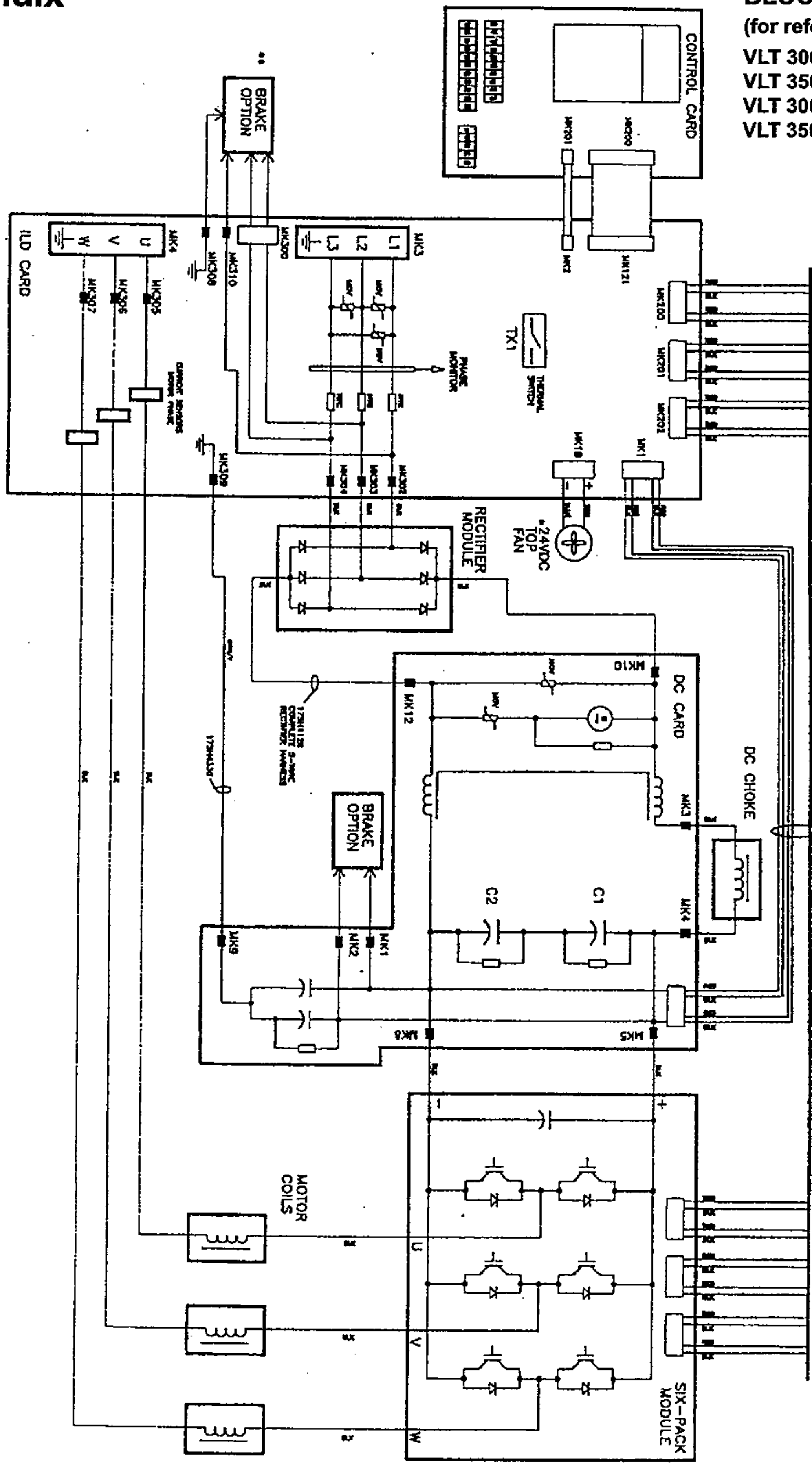


17. Standoff, ILD Card to Ground
18. Motor Coil
19. Rectifier Module
20. Standoff, DC Card
21. IGBT Six-Pack Module

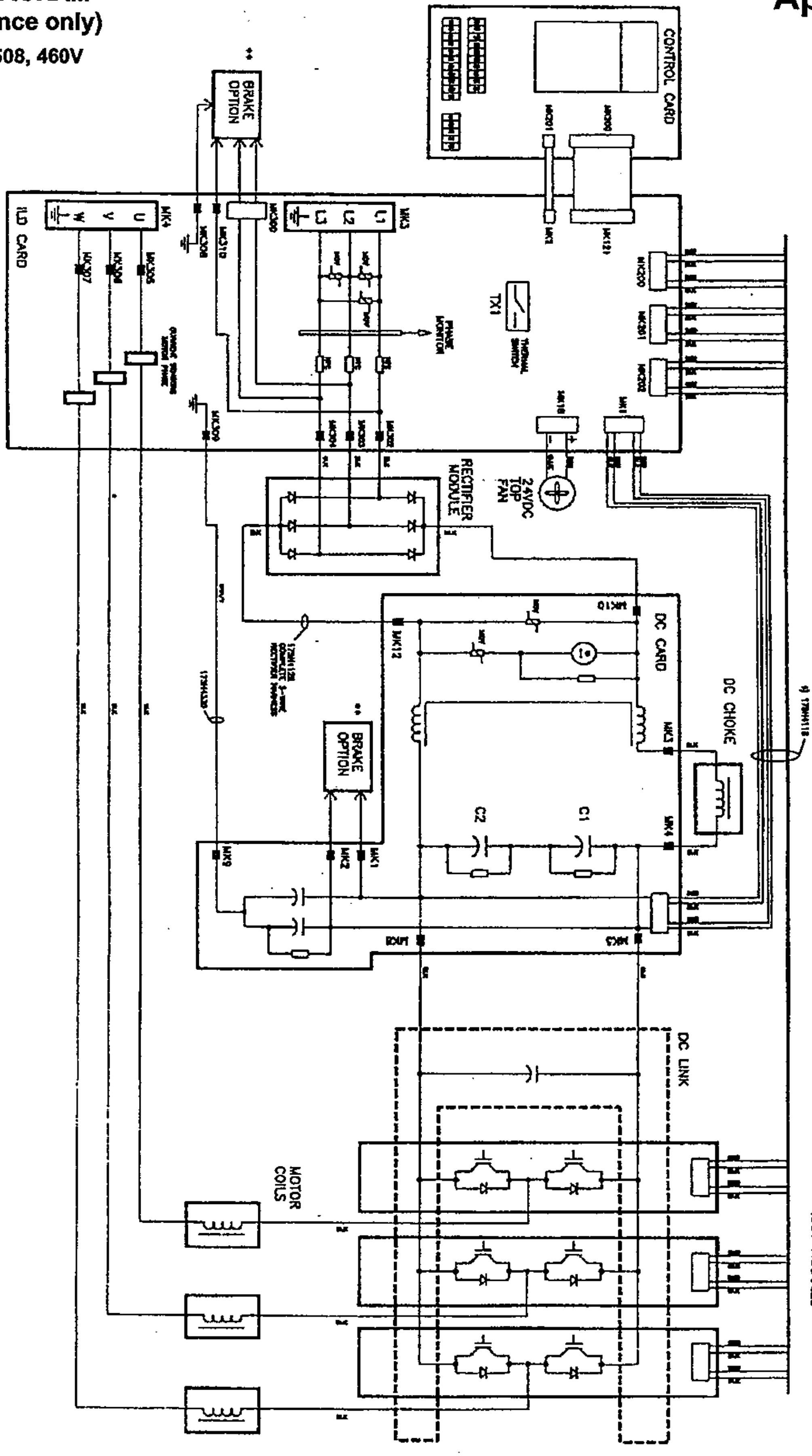
BLOCK DIAGRAM

(for reference only)

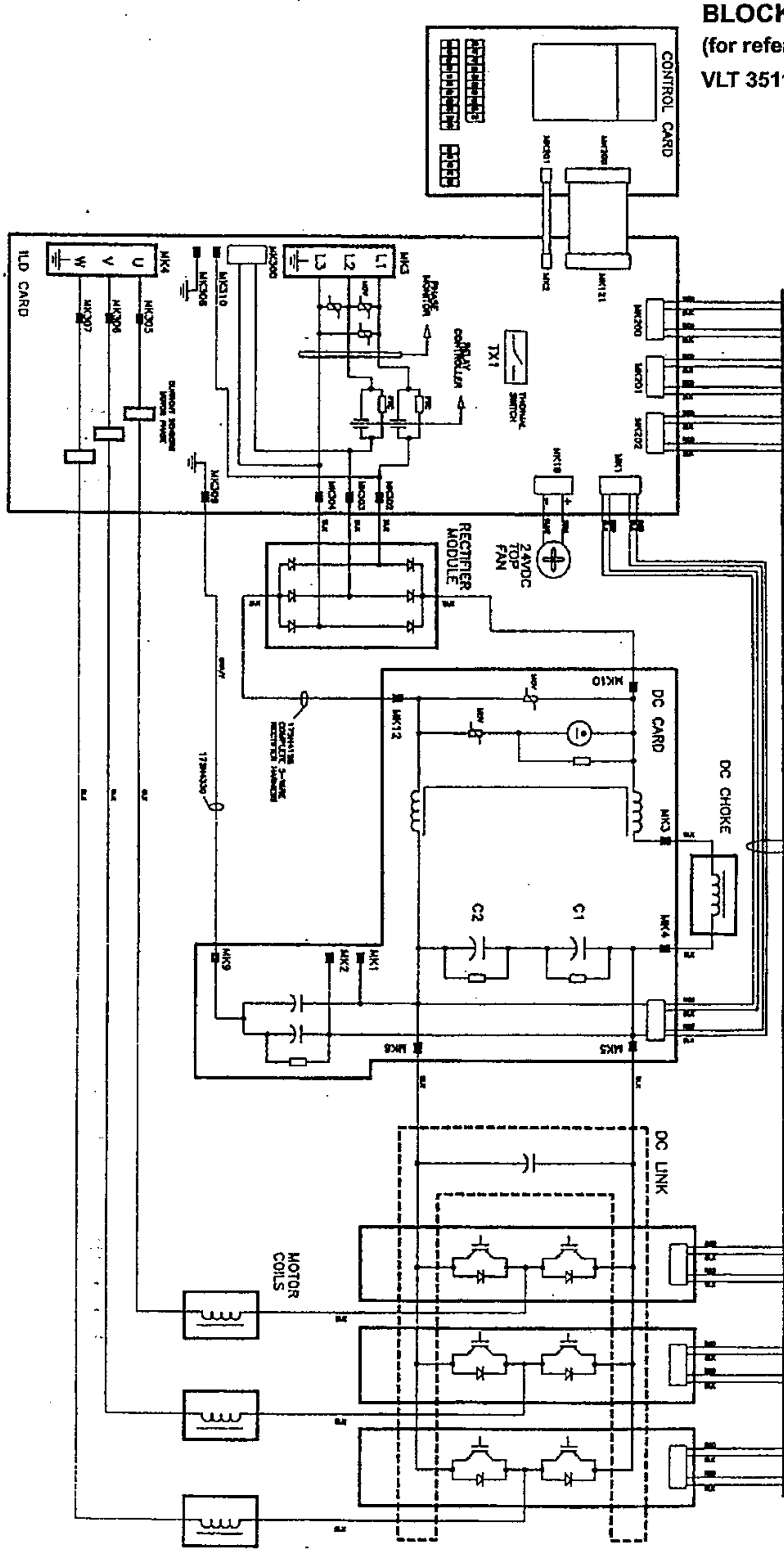
VLT 3002-3004, 230V
VLT 3502-3504, 230V
VLT 3002-3006, 460V
VLT 3502-3506, 460V



BLOCK DIAGRAM
(for reference only)
VLT 3008, 3508, 460V



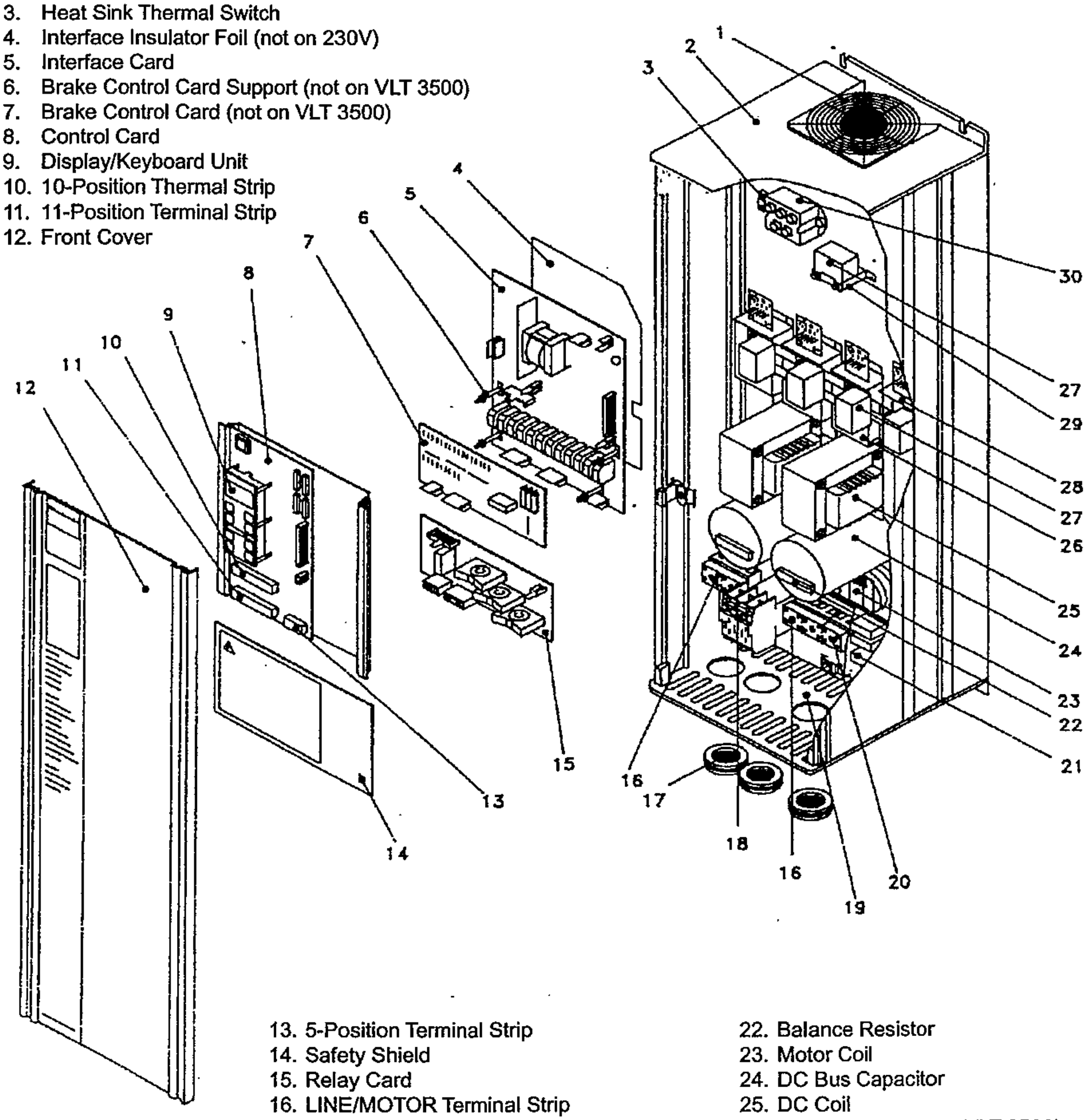
BLOCK DIAGRAM
(for reference only)
VLT 3511, 460V



COMPONENT LOCATION

VLT 3006-3022, 230V **VLT 3508-3532, 230V**
VLT 3011-3052, 380/460V **VLT 3516-3562, 380/460V**

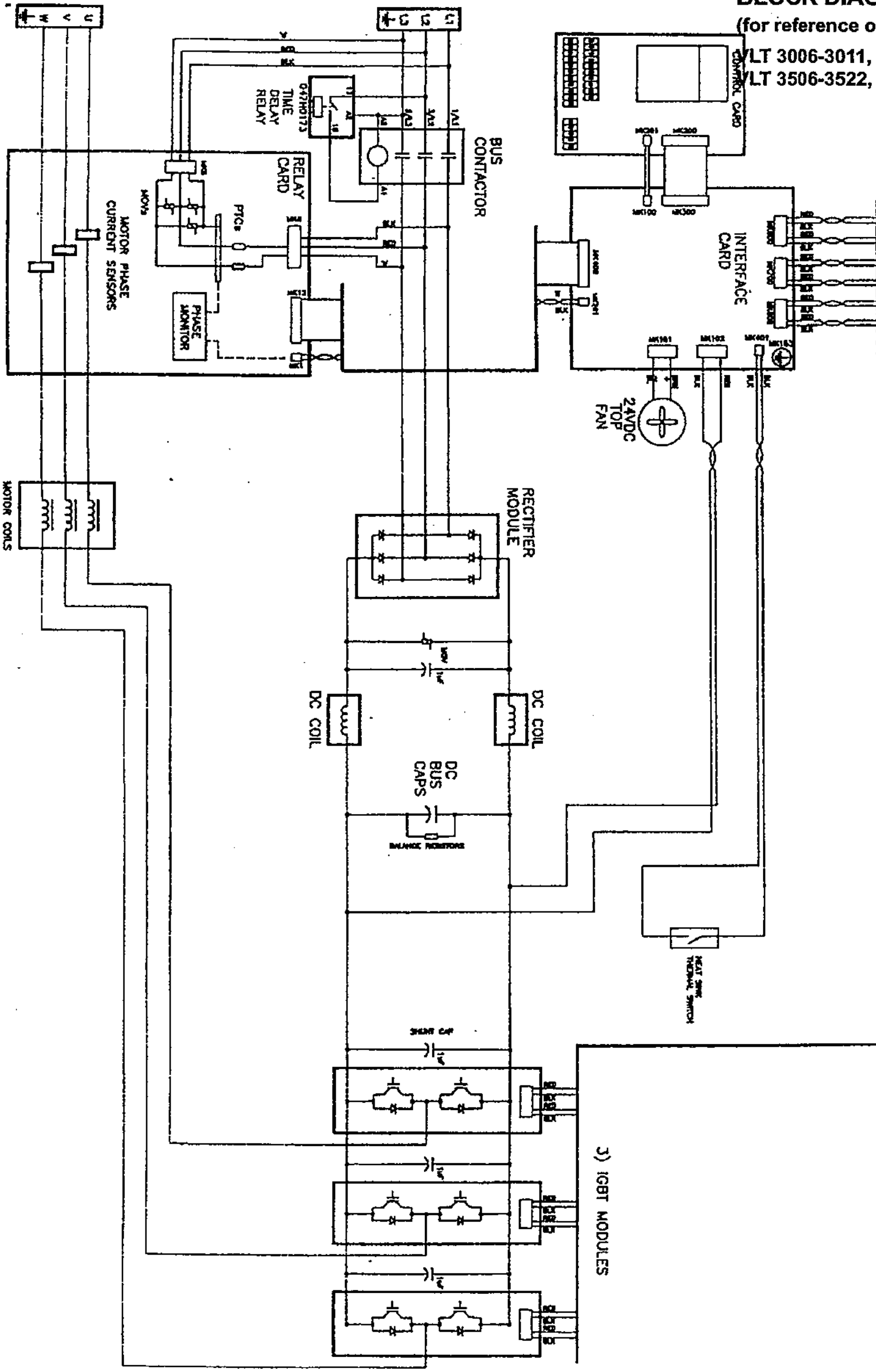
1. Top fan
2. Top Cover
3. Heat Sink Thermal Switch
4. Interface Insulator Foil (not on 230V)
5. Interface Card
6. Brake Control Card Support (not on VLT 3500)
7. Brake Control Card (not on VLT 3500)
8. Control Card
9. Display/Keyboard Unit
10. 10-Position Thermal Strip
11. 11-Position Terminal Strip
12. Front Cover



13. 5-Position Terminal Strip
14. Safety Shield
15. Relay Card
16. LINE/MOTOR Terminal Strip
17. Rubber Grommet
18. Bus Contactor
19. Bottom Cover
20. BRAKE Terminal Strip (not on VLT 3500)
21. RFI Option
22. Balance Resistor
23. Motor Coil
24. DC Bus Capacitor
25. DC Coil
26. Brake IGBT (not on VLT 3500)
27. Clamp Capacitor
28. IGBT Module
29. MOV
30. Rectifier Module

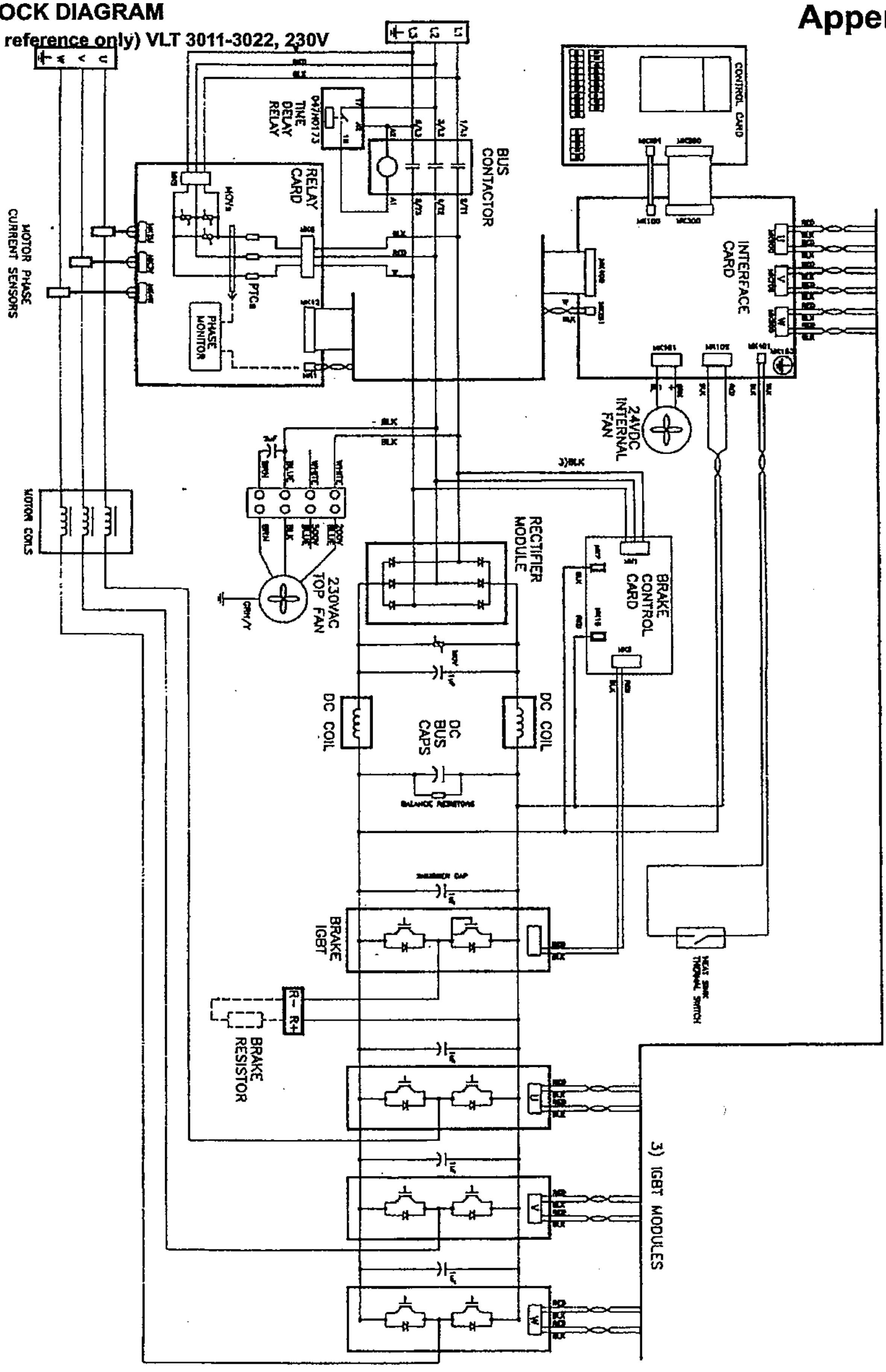
Appendix

BLOCK DIAGRAM
(for reference only)
VLT 3006-3011, 230V
VLT 3506-3522, 230V

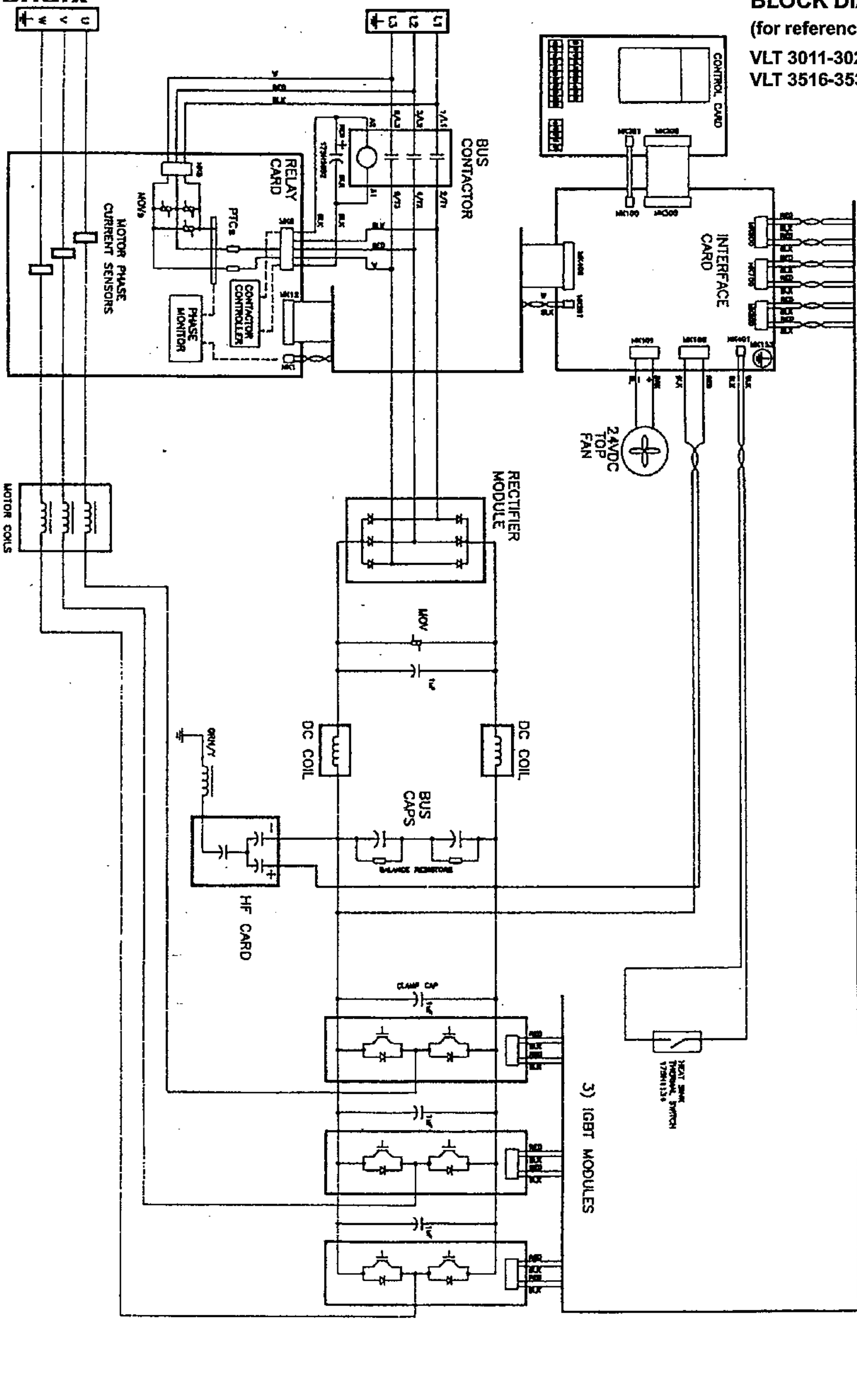


BLOCK DIAGRAM

(for reference only) VLT 3011-3022, 230V

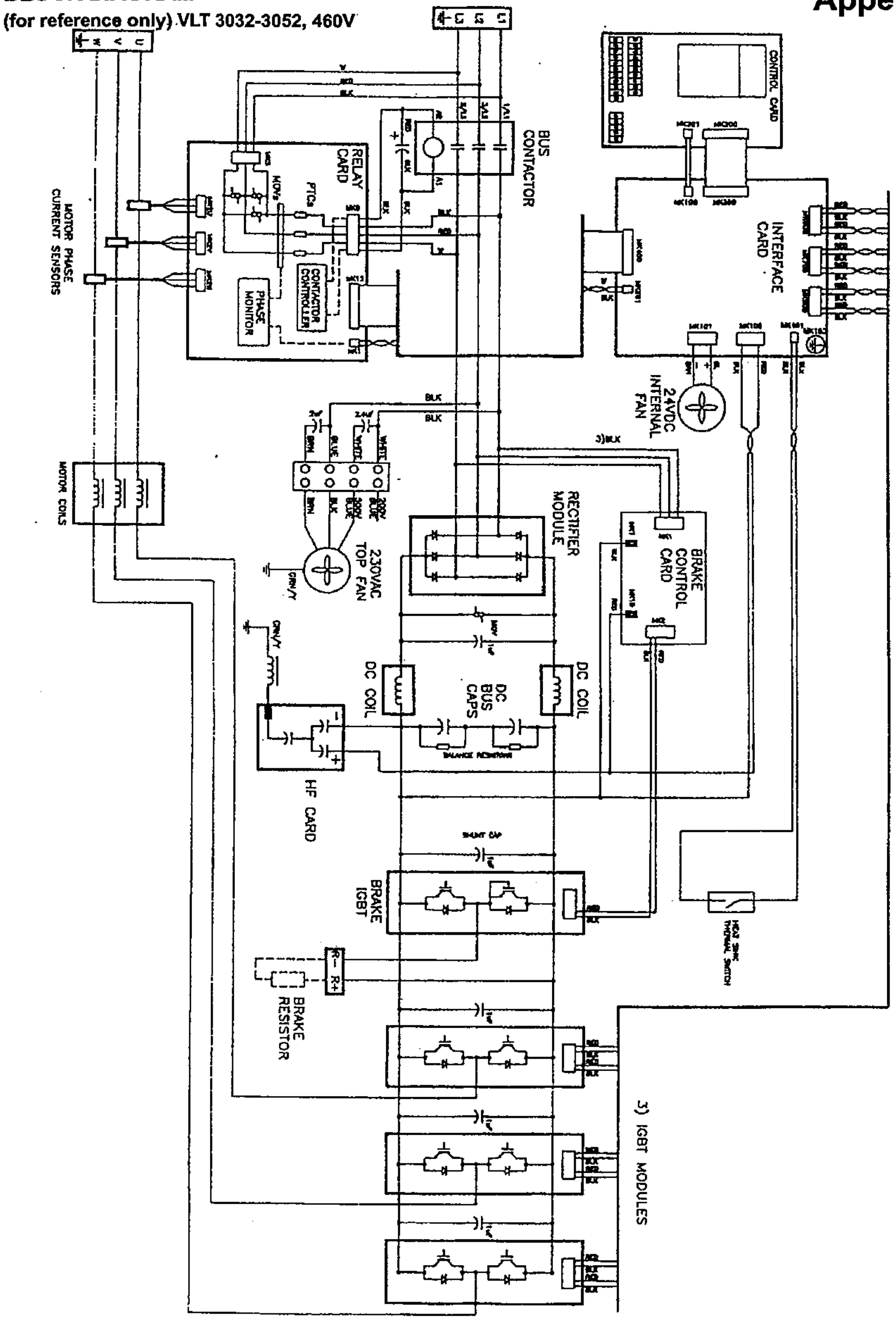


BLOCK DIAGRAM
(for reference only)
VLT 3011-3022, 460V
VLT 3516-3532, 460V



BLOCK DIAGRAM

(for reference only) VLT 3032-3052, 460V

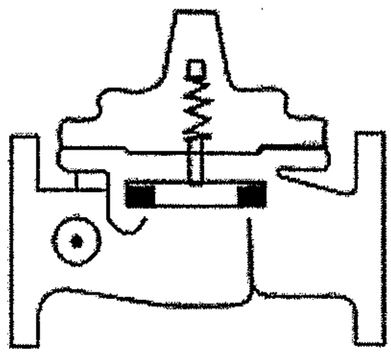


CLA-VAL

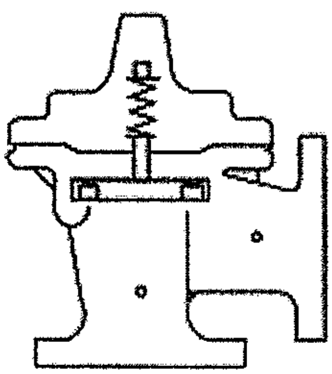
AUTOMATIC CONTROL VALVES

61-02/661-02

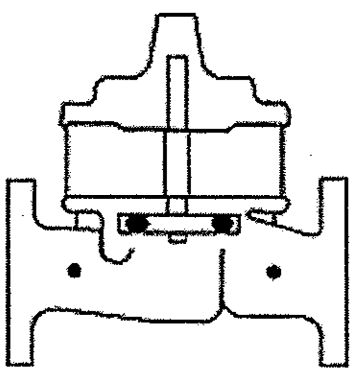
Place this manual with personnel responsible for maintenance of this valve



INSTALLATION



OPERATION



MAINTENANCE

CLA-VAL™

CLA-VAL ▼ P.O. BOX 1325 ▼ NEWPORT, CA 92659-0325 ▼ (949) 722-4800 ▼ FAX: (949) 548-5441
CLA-VAL CANADA LTD. ▼ 4687 Christie Drive ▼ Beamsville, Ontario, L0R 1B4 Canada ▼ (905) 563-4963

CVCL 1 (2) 3 4 DIST. CODE 002 SHEET 1 OF 3

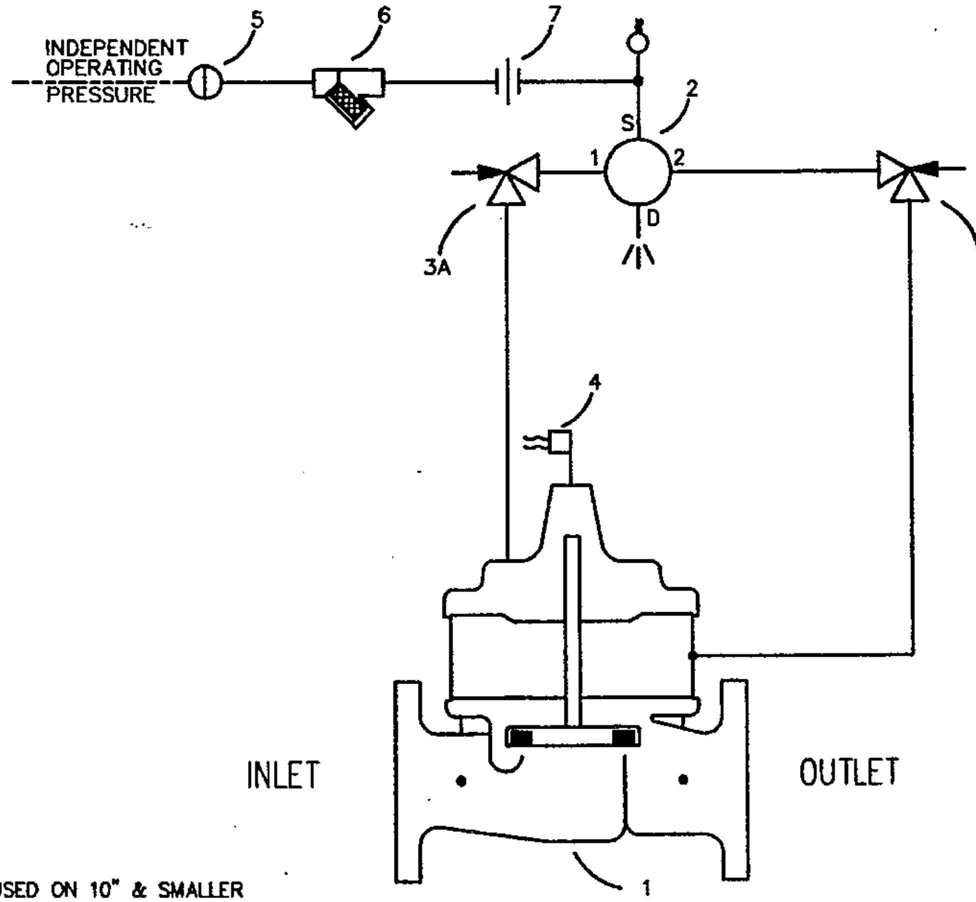
CLA-VAL CO. NEWPORT BEACH, CALIFORNIA	CATALOG NO. 61-02/661-02	DRAWING NO. 96380	REV. A

TYPE OF VALVE AND MAIN FEATURES

DEEP WELL PUMP CONTROL VALVE

DESIGN		
DRAW	JD	6-2-78
CHK'D	CH	6-7-78
APVD	HWE	6-7-78

——— NOT FURNISHED BY CLA-VAL CO. – – – – OPTIONAL FEATURES



* USED ON 10" & SMALLER

** USED ON 12" & SMALLER

ITEM NO.	BASIC COMPONENTS	
1	*100-02 POWERTROL (61-02) MAIN VALVE **100-21 POWERTROL (661-02) MAIN VALVE	1
2	CSM11-A2-2 SOLENOID CONTROL	1
3	CV FLOW CONTROL	2
4	X105LOW SWITCH ASSEMBLY	1
5	CK2 COCK (ISOLATION VALVE)	1
6	X43 "Y" STRAINER	1
7	UNION	1

OPTIONAL FEATURE SUFFIX ADDED TO CATALOG NUMBER

CAD REVISION RECORD - DO NOT REVISE MANUALLY

LTR	DESCRIPTION	BY	DATE
A	REDRAW ON CAD; ADDED CAT NO. 661-02 & 100-21 HYTROL TO ITEM 1; ADDED SIZE LIMITS (ECO 16108)	EK	10-17-96

CLA-VAL CO. NEWPORT BEACH, CALIFORNIA	CATALOG NO. 61-02/661-02	DRAWING NO. 96380	REV. A
TYPE OF VALVE AND MAIN FEATURES: DEEP WELL PUMP CONTROL VALVE	DESIGN		
	DRAW	JD	6-2-78
	CHK'D	CH	6-7-78
	APV'D	HWE	6-7-78

OPERATING DATA

I. SOLENOID CONTROL FEATURE:

SOLENOID CONTROL (2) IS A DIRECT ACTING 4-WAY SOLENOID CONTROL THAT CHANGES POSITION WHEN THE COIL IS ENERGIZED OR DE-ENERGIZED. THIS APPLIES OR RELIEVES PRESSURE IN THE COVER CHAMBER OR POWERTROL CHAMBER OF THE MAIN VALVE (1) PROVIDING THE OPERATION SHOWN IN THE FOLLOWING TABLE:

SOLENOID CONTROL (2)		MAIN VALVE (1)		
POSITION	PORTS CONNECTED	POWERUNIT CHAMBER	COVER CHAMBER	POSITION
ENERGIZED	"S" & "1" "2" & "D"	PRESSURE RELIEVED	PRESSURE APPLIED	CLOSED
DE-ENERGIZED	"S" & "2" "1" & "D"	PRESSURE APPLIED	PRESSURE RELIEVED	OPEN

II. SOLENOID MANUAL OPERATOR:

TO MANUALLY OPERATE THE SOLENOID, PRESS DOWN ON THE KNURLED KNOB LOCATED ON TOP OF THE COIL ENCLOSURE AND TURN CLOCKWISE 1/4 TURN. TO RETURN THE SOLENOID TO ELECTRICAL CONTROL, TURN THE KNURLED KNOB CLOCKWISE 1/4 TURN AND THE KNURLED KNOB WILL RETURN TO THE ORIGINAL POSITION.

III. OPENING SPEED CONTROL:

CV FLOW CONTROL (3A) CONTROLS THE OPENING SPEED OF THE MAIN VALVE. TURN THE ADJUSTING STEM CLOCKWISE TO MAKE THE MAIN VALVE OPEN SLOWER.

IV. CLOSING SPEED CONTROL:

CV FLOW CONTROL (3B) CONTROLS THE CLOSING SPEED OF THE MAIN VALVE. TURN THE ADJUSTING STEM CLOCKWISE TO MAKE THE MAIN VALVE CLOSE SLOWER.

V. SWITCH ASSEMBLY FEATURE:

SWITCH ASSEMBLY (4) IS ACTUATED BY A STEM EXTENSION ATTACHED TO THE MAIN VALVE STEM. THE SWITCH ASSEMBLY IS FACTORY ADJUSTED TO ACTUATE A SINGLE-POLE, DOUBLE-THROW SWITCH WHEN THE MAIN VALVE IS ALMOST OPENED. WHEN THE MAIN VALVE STARTS TO CLOSE, THE SPRING LOADED SWITCH ACTUATING LEVER IS RELEASED AND RETURNS THE SWITCH TO ITS NORMAL POSITION.

CAD REVISION RECORD - DO NOT REVISE MANUALLY

LTR	DESCRIPTION	BY	DATE
	SEE SHEET 1.		

CLA-VAL CO. NEWPORT BEACH, CALIFORNIA

CATALOG NO.	DRAWING NO.	REV.
61-02/661-02	96380	A

TYPE OF VALVE AND MAIN FEATURES

DEEP WELL PUMP CONTROL VALVE

DESIGN		
DRAW	JD	6-2-78
CHK'D	CH	6-7-78
APVD	HWE	6-7-78

CAD REVISION RECORD - DO NOT REVISE MANUALLY

LTR	DESCRIPTION	BY	DATE
	SEE SHEET 1.		

OPERATING DATA-CONTINUED

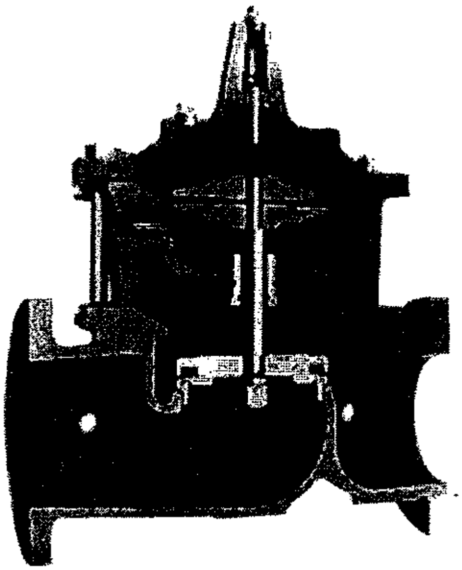
VI. CHECK LIST FOR PROPER OPERATION:

( ) SYSTEM VALVES OPEN UPSTREAM AND DOWNSTREAM.
( ) AIR REMOVED FROM THE MAIN VALVE COVER AND PILOT SYSTEM AT ALL HIGH POINTS.
( ) PERIODIC CLEANING OF STRAINER (6) IS RECOMMENDED.
( ) CK2 COCK (5) OPEN DURING NORMAL OPERATION.
( ) CORRECT VOLTAGE TO SOLENOID CONTROL (2).
( ) MANUAL OPERATOR OF SOLENOID CONTROL (2) DISENGAGED.
( ) INDEPENDENT OPERATING PRESSURE LINE PROPERLY CONNECTED.
( ) CV FLOW CONTROL (3A) & (3B) OPEN AT LEAST 1/4 TURN.

CLA-VAL

— MODEL — 100-02

Powertrol Valve



DESCRIPTION

This manual contains information for installation, operation and maintenance of the Cla-Val Co. 100-02 Powertrol, an automatic valve designed for use where independent operating pressure is desired,or when line fluid is unsuitable as an operating medium.

This valve is a hydraulically operated, diaphragm type, globe or angle pattern valve. it is single seated and incorporates into its design two operating chambers sealed from one another by a flexible synthetic rubber diaphragm. Pressure applied to the upper chamber closes the valve; when applied to the lower chamber, it opens the valve.

With proper pilot controls, the valve can be held in any intermediate position between fully open and tightly closed.

INSTALLATION

1. Allow sufficient room around the valve assembly to make adjustments and for disassembly.

   NOTE: BEFORE THE VALVE IS INSTALLED, PIPE LINES SHOULD BE FLUSHED OF ALL CHIPS, SCALE AND FOREIGN MATTER.

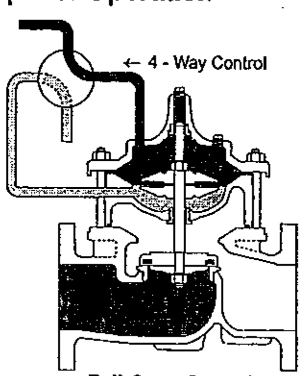
2. It is recommended that gate or block valves be installed on both the upstream and downstream sides of the 100-02 to facilitate isolating the valve for preventative maintenance.
3. Place the valve in the line with flow through the valve in the direction indicated on the inlet name plate or by flow arrows.
4. Cla-Val Powertrol Valves operate with maximum efficiency when mounted in horizontal piping with cover "UP,' however, other positions are acceptable. Due to the size and weight of the cover and internal assembly of 4" and larger valves, installation with the cover "UP" is advisable. This makes periodic inspection of internal parts readily accessible.
5. When a pilot control system is installed on the Powertrol Valve, use care to prevent damage. If it is necessary to remove fittings or components, be sure they are kept clean and replaced in the exact order of removal.
6. After the valve is installed and the system is first pressurized, vent air from the cover chamber and tubing by loosening fit" sings at all high points.

TROUBLE SHOOTING

The following trouble shooting information deals strictly with the Powertrol Valve; however some 'impossible causes" will refer to components that may exist in the variety of control systems available for the valve. All trouble shooting is possible without removing the valve from the line.

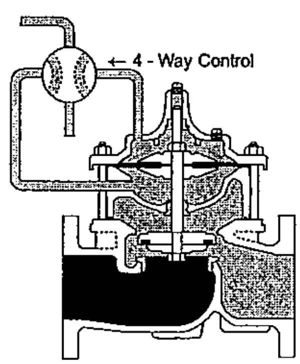
CAUTION: Extreme care should be taken when servicing the valve. Gate or line block valves must be closed upstream and downstream of the valve before starting disassembly. When there are no block or gate valves to isolate the Powertrol Valve it should be realized that the valve cannot be serviced under pressure. Steps must be taken to remedy this situation before proceeding.

Principle of Operation



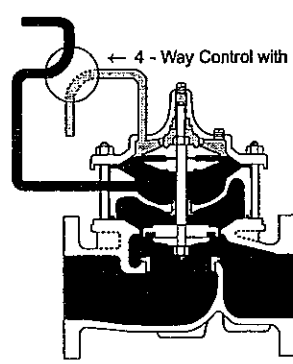
Full Open Operation

When operating pressure below the diaphragm is applied and operating, pressure is relieved from the cover chamber, the valve is held open, allowing full flow.



Tight Closing Operation

When pressure below the diaphragm is relieved and operating pressure is applied to the cover chamber, the valve closes drip-tight.



Modulating Action

The valve holds any intermediate position when operating pressure is equal above and below the diaphragm. A Cla-Val four-way pilot control with "lock" position can maintain this balance by stopping flow in the pilot control system.

SYMPTOM	*POSSIBLE CAUSE	TEST PROCEDURE	REMEDY
Valve fails to close.	Stem stuck in open position.	Vent power unit chamber. Apply pressure to cover chamber. Valve should close.	Disassemble, examine all internal parts for cause of the sticking condition and clean off scale deposits.
	Worn diaphragm or loose upper stem nut	Apply pressure in power unit chamber and vent cover. Continuous flow from cover indicates this trouble.	Disassemble and replace diaphragm or tighten the valve stem nut.
	Foreign object on valve seat.	Valve opens okay but only closes part way.	Try operating valve a few times. This might dislodge the object. If this fails, disassemble and remove the obstruction.
	Pressure not being released from power unit chamber.	Make sure pressure is being released by opening a fitting into the chamber. If valve then closes refer to remedy.	Check control system. Tube line or nipple might be plugged up.
	Operating pressure not getting into valve cover.	Use pressure gauge or loosen cover plug to check for pressure.	Clean tubing or pipe fittings into cover chamber. Open CK2 Cocks in control lines.
	Insufficient line pressure.	Check line pressure.	Establish line pressure.
Valve fails to open.	Stem stuck in closed or semi-open position.	Vent cover. Apply pressure to power unit chamber.	Disassemble, examine all internal parts for cause of the sticking pro bleary, and clean off scale deposits.
	Worn diaphragm or loose upper stem nut.	Apply pressure in power unit chamber and vent cover. Continuous flow from cover indicates this pro bleary.	Disassemble and replace diaphragm or tighten valve stem nut.
	Foreign object on top of disc retainer	Valve closed okay but won't open all the way.	Try operating valve a few times. This might dislodge the object. if this fails disassemble and remove the obstruction.
	Pressure not being released from cover chamber.	Open a fitting or remove a plug from cover chamber if cover chamber vents and valve opens, see remedy.	Check control system. Check lines or pipe fittings. Clean out any plugged lines.
	Operating pressure not applied into power unit chamber.	Loosen a fitting in this chamber to check for pressure at this point.	Clean tubing or pipe fittings into power unit chamber.
Valve closes but leakage occurs.	Worn disc or seat.	The best procedure here is to disassemble the valve and inspect these parts.	Replace worn parts.
O-Ring failure	Mineral deposits on stem cause abrasion on ring.	Remove pressure from both cover and power unit chambers and apply line pressure to valve. Open line from power unit chamber and observe continuos flow.	Disassemble and replace O-ring.

*Assuming control system is functioning properly.

FREEDOM OF MOVEMENT

The following procedures can be used to determine if the valve opens and closes fully. During this test the diaphragm can be checked for damage.

1.The Powertrol Valve will have a control to open and close the valve. Position the control so that pressure is applied to the cover chamber (above the valve diaphragm). This will close the Powertrol Valve. Check the drain from the control that discharges to atmosphere.

Once the liquid from the lower diaphragm chamber is drained the discharge should stop. If the discharge continues after the normal time it takes to drain then the diaphragm is damaged, or the stem nut is loose, or the stem o-ring is leaking. If the discharge is continuous from both chambers then there is a possibility that the diaphragm or the pilot control is damaged.

If the valve is equipped with a "Dry Drain" (control drain piped to downstream end of the valve) then same procedure is followed except the CK2 Shutoff Cock on the downstream end of the valve must be closed and the drain line disconnected and drained to atmosphere. It can then be checked as above.

Measurement of the vertical travel of the stem (diaphragm assembly) will make it possible to determine if the travel, or stroke is restricted. The following chart provides this measurement. It is necessary to have either the X101 Valve Position Indicator or X105 Limit Switch Assembly installed on the valve to visually check the travel.

Mark the position of the stem on the X101 or X105 when the valve is closed. Reposition the control so that pressure is applied below the diaphragm and the cover chamber is drained. Determine the extent of the stem travel. Check this movement with the stem travel chart. If the stroke is different than listed (5% to 10%) then there is good reason to believe something is mechanically restricting the stroke of the valve at one end of its travel. If it is determined that flow does not stop through the valve when in the indicated "closed" position, the obstruction probably is between the disc and the seat, or in the power unit chamber below the diaphragm. If the flow stops, the obstruction is likely in the cover chamber above the diaphragm or possibly above the disc retainer. Refer to the sectional view under Principle of Operation.

If operation of the valve a few times does not dislodge the foreign object obstructing the diaphragm assembly (stem) movement then the valve must be disassembled and the problem located and corrected. See disassembly instructions.

STEM TRAVEL
(Fully open to fully closed)

VALVE SIZE INCHES	MM	VALVE SIZE INCHES	MM
1	25	0.3	8
1 1/4	32	0.4	10
1 1/2	40	0.4	10
2	50	0.6	15
2 1/2	65	0.7	18
3	80	0.8	20
4	100	1.1	23
6	150	1.7	43
8	200	2.3	58
10	250	2.8	71
12	300	3.4	86
14	350	3.9	99
16	400	4.5	114

MAINTENANCE

Preventative Maintenance

The Cla-Val Co Powertrol Valves require no lubrication or packing and a minimum of maintenance. However, a periodic inspection schedule should be established to determine how the fluid velocity as well as the substances occurring in natural waters are affecting the valve These substances can be dissolved minerals. colloidal and suspended particles. Effect of these actions or substances must be determined by inspection.

DISASSEMBLY

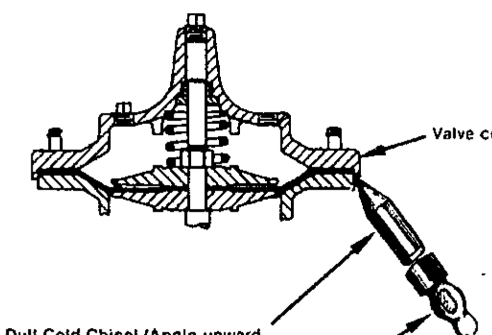
1. First mark the side of the valve cover, power unit body and valve body so that reassembly of these parts will be exactly as removed.

2. The Powertrol Valve inspection or maintenance can be accomplished without removal of the valve body from the line. Shut off pressure to the valve, both inlet, outlet and independent operating pressure when used.

WARNING: Maintenance personnel can be injured and equipment and property damaged if disassembly is attempted with pressure in the system.

3. After pressure has been released from the valve control system and operating chambers of the valve, remove the controls and tubing. Obtain a schematic of the assembly or note and sketch position of tubing and controls for reassembly. Replacing tubing into the control ports exactly as removed is necessary. Failure to reassemble properly will cause the valve to malfunction and possibly cause serious damage.

4. Remove cover nuts and cover. if the valve has been in service for any length of time, chances are the cover will have to be loosened by driving upward along the edge of the cover with a dull cold chisel. See Figure 1.



When block and tackle or a power hoist is to be used to lift the valve cover insert a proper size eye bolt in place of the center cover plug. Pull cover straight up to keep from damaging the power unit stem bearing and upper stem.

On valves 1" and larger remove the power unit retaining nuts. The power unit body can now be lifted from the valve body. The stem with diaphragm assembly and disc retainer assembly will be removed with the power unit body.

CAUTION: During service performed on the stem assembly, the stem surfaces must not be damaged. If a vice or other holding device is used to grip the stem, soft jaws of brass or copper must be used to protect the precision ground surface of the stainless steel stem. If the stem is marred no amount of careful dressi,pg can restore the stem to its original condition.

6. Inspect the threads on the stem. Mineral deposits that prevent the nuts from turning must be cleaned from the threads A 5C.h solution of muriatic acid will soften mineral or scale deposits to assist in removal of nuts and general cleaning of parts. Flush the parts thoroughly with water immediately after cleaning.

Care must always be exercised when handling acid. Read the warning label on the acid container to be sure of correct method of use and disposal after use.

7. Remove the upper stem nut, upper diaphragm washer, diaphragm and lower diaphragm washer. The stem with the disc retainer assembly can now be removed from the power unit body

8. Hold the stem in a vice with soft jaws and remove the lower stem nut. Remove the lock washer, disc retainer, space washer(s) and disc Refer to the sectional view of the valve size being serviced. This will assist in the disassembly procedure outlined above. The reassembly instructions outlining proper procedure and quantity of space washers. This is especially important if the disc is replaced.

Inspection of Parts

1. Returning to the valve body in the line, the seat should now be inspected for damage. if the seat requires removal use the following tools. Seats in valve sizes 1/2" and 3/4" can be removed with a hex socket wrench. Seats in valve sizes 1" through 6" should be removed with accessory X-109 Seat Removing Tool available from the factory. Seats in valve sizes 3" through 16" may be removed with a screw driver. If upon removal of the screws the seat cannot be lifted out, it will be necessary to use a hard rubber mallet and tap the seat loose.

2. Any buildup of mineral or scale should be cleaned from the valve body at this time. Inspection of the cover and power unit body surfaces that contact the diaphragm is important. Clean and smooth, with wet or dry emery paper, any roughness that could damage the diaphragm. Inspect and recondition the surface on the upper and lower diaphragm washers. The perimeter of the diaphragm washers is the most likely area to cause diaphragm wear if the surface is not smooth. Take extra care to make this a smooth finish.

3. Inspect the power unit body bearing insert o-ring that is in contact with the stem. If it is worn, nicked or cut, replace it.

4. Inspect the diaphragm for cracks or chafing. Replace the diaphragm if damaged.

Inspect the disc and replace if the surface Is damaged or worn. If a new disc is not available, the existing disc can be turned over, exposing the unused surface for contact with the seat.

6. The disc guide should be checked and cleaned of scales and mineral deposits. Due to the close tolerance between the outer periphery of the disc guide and the inner area of the valve seat, no scale or mineral deposits should be overlooked.

REASSEMBLY

To reassemble, reverse the order of disassembly.

1. If the disc has been removed, it is important that correct pressure be on the disc from the disc guide when the lower stem nut is tight. Use sufficient spacer washers to obtain slight pressure (by visual indentation) on the disc. This applies to 1" through 16" valves. Refer to seat and disc detail drawings for location of spacer washers for various valve sizes.

Note: New discs will usually require a different number of spacer washers to obtain the right amount of 'grip (slight indentation) on the disc.

1. If the disc has been removed, it is important that correct pressure be on the disc from the disc guide when the lower stem nut is tight. Use sufficient spacer washers to obtain slight pressure (by visual indention) on the disc. Indention should be slight and no looseness evident. This adjustment applies to 1 " through 16". Refer to seat and disc detail drawings for location of spacer washers for various valve sizes.

NOTE: New discs will usually require a different number of spacer washers to obtain the right amount of "grip" on the disc.

2. The stem, with the disc assembly, can now be inserted through the power unit body. Note sectional view for correct position of the power unit body and stem assembly

3. Install on the cover end of the stem the lower diaphragm washer,the diaphragm, the upper diaphragm washer, then screw on the upper stem nut.

4. Tighten the upper stem nut securely so the diaphragm and upper and lower diaphragm washer cannot be turned on the stem. During the tightening of the upper stem nut the lower stem nut can be held in a vice, or with a second wrench.

5. Replace the gasket on the body. If an o-ring seal is used as a gasket, valve size 4" through 16", a light coating of grease can be applied to the power unit body groove to hold the o-ring in place while installing on the body. The power unit body must be replaced so that the index marks applied in Disassembly Step 1 align. The control tubing will then be able to be reassembled without difficulty.

6. Replace cover chamber spring on the upper diaphragm washer. NOTE: Some valves may not have a cover chamber spring.

7. Place the cover on the power unit body aligning the index marks. Secure the cover with 8 stud nuts. Tighten the nuts firmly with a cross-over pattern until all nuts are tight:

8. Reinstall the control system and tubing exactly as it was before disassembly.

ITEM NO.	DESCRIPTION
1	HEX NUT 10-32 (8)
2	COVER
3	POWER UNIT BODY
4	HEX NUT 1/4-28-NF-2 A.S.F. JAM
5	DIAPHRAGM WASHER (UPPER)
6	DIAPHRAGM
7	DIAPHRAGM WASHER (LOWER)
8	STEM
9	DISC GUIDE
10	DISC RETAINER ASSEMBLY
11	"O" RING
12	BODY TO BODY GASKET
13	STUD 10-32 (8)
14	PIPE PLUG 1/8 NPT
15	BODY
16	SPRING (USED ON 100-02KHR & 100-02 KHX
17	"O" RING
18	SEAT
19	NAMEPLATE

9.The Powertrol Valve can be tested for tight closure as well as the tightness of the seal across the diaphragm.

a.The downstream or outlet shutoff valve remains closed

b. If the control system has a pilot or control that can position the valve to a closed position, put the control in a position to close the Powertrol. Lacking a control, inlet pressure must be tubed to the Powertrol cover.

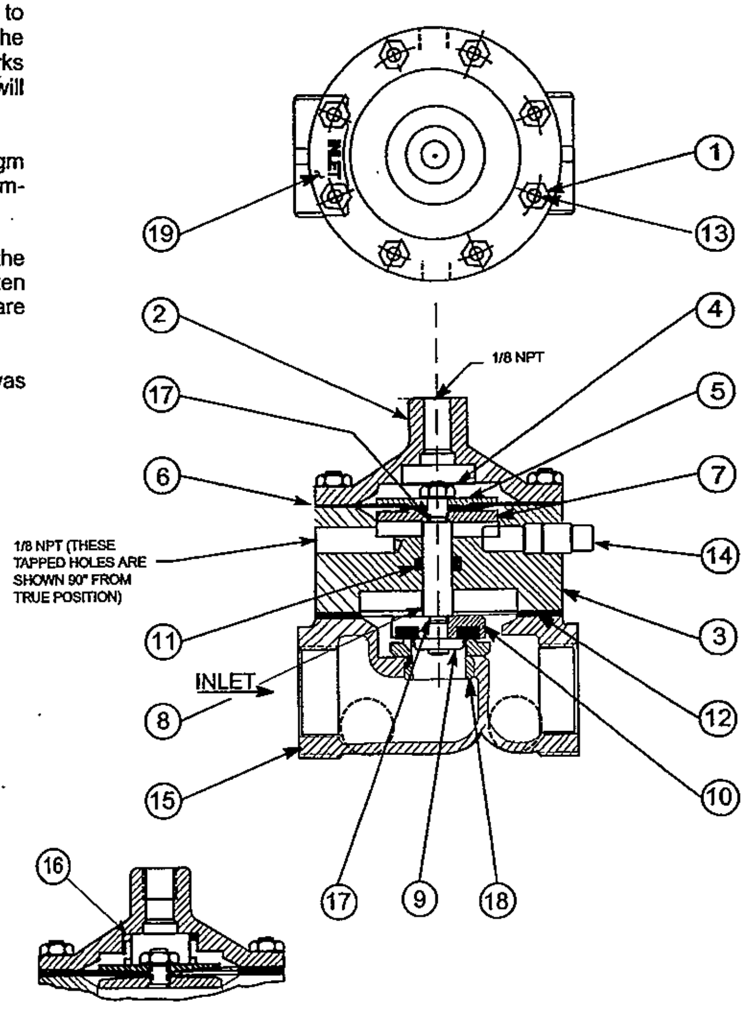
c. Open upstream gate or line block valve just enough to allow flow.

d. Have the power unit body, center section, open to atmosphere The power unit body will be atmospheric if the control is being used.

e. Partially disconnect a fitting on the discharge side of the valve. Do not remove fully unless there is no pressure.

f. After the valve is in the closed position for a few minutes, all draining of the power unit body should stop. This will indicate a good seal across the valve seat and the diaphragm.

100-02 POWERTROL
VALVE SIZES 1/2" & 3/4"



MODELS 100-02KH 100-02KHR, 100-02KHX

USEFUL INFORMATION OR HINTS

1. The approximate volume of liquid discharged from the chamber above the diaphragm when the valve moves from the fully closed positions to the fully open is as follows:

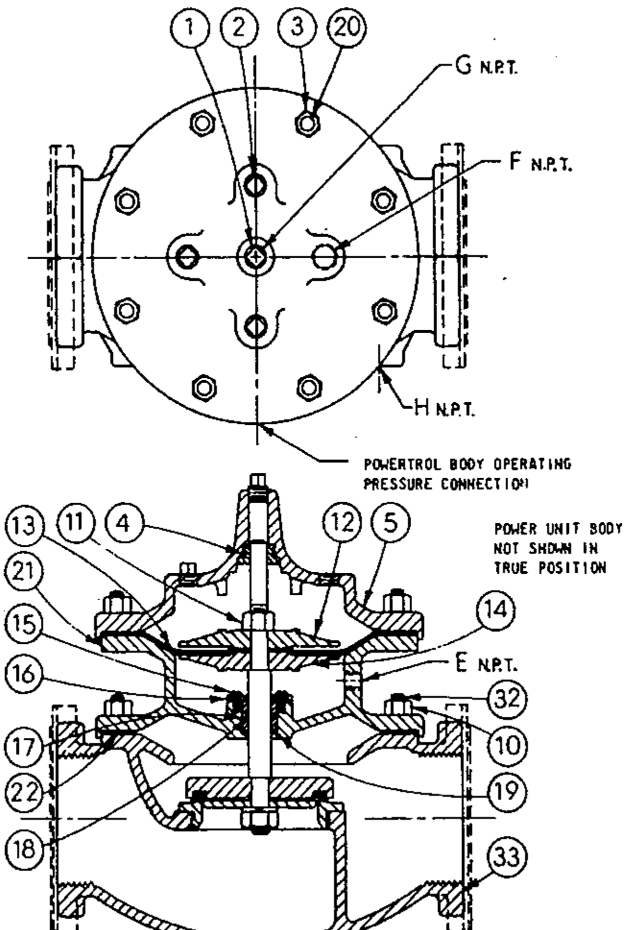
VALVE SIZE	DISPLACEMENT	
1/2"	0.340 Fl. Oz	.01 Liters
3/4"	0.340 Fl. Oz.	.01 Liters
1"	0.700 Fl. Oz.	.02 Liters
1 1/4"	0.020 Gal.	.10 Liters
1 1/2"	0.020 Gal.	.10 Liters
2"	0.032 Gal.	.10 Liters
2 1/2"	0 043 Gal	.20 Liters
3"	0.080 Gal	.30 Liters
4"	0.169 Gal.	.60 Liters
6"	0 531 Gal.	2.00 Liters
8'	1.260 Gal	4.75 Liters
10"	2.510 Gal.	9.50 Liters
12"	4.000 Gal.	15.14 Liters
14"	6.500 Gal.	24.60 Liters
16"	9.570 Gal.	36.20 Liters

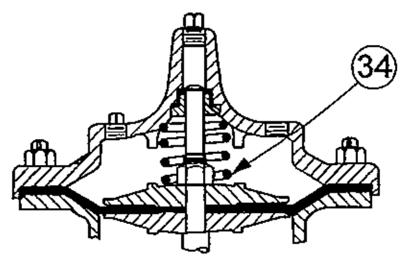
PARTS LIST

1	CENTER COVER PLUG
2	COVER PLUG
3	COVER RETAINING NUT
4	COVER BEARING NUT
5	COVER
10	POWER UNIT RETAINING NUT
11	UPPER STEM NUT
12	UPPER DIAPHRAGM WASHER
13	DIAPHRAGM
14	LOWER DIAPHRAGM WASHER
15	BEARING RETAINER WASHER
16	BEARING RETAINER
17	BEARING INSERT
18	"O" RING
19	BEARING GASKET
20	POWER UNIT COVER STUD
21	POWER UNIT BODY
22	GASKET (BODY TO POWER UNIT)
23	LOWER STEM NUT
24	SPACER WASHER
26	DISC GUIDE
27	DISC RETAINER
28	DISC
29	STEM
31	SEAT
32	BODY TO POWER UNIT STUD
33	BODY
34	SPRING (USED ON MODELS 100-02KH
35	LOCK WASHER - SPRING

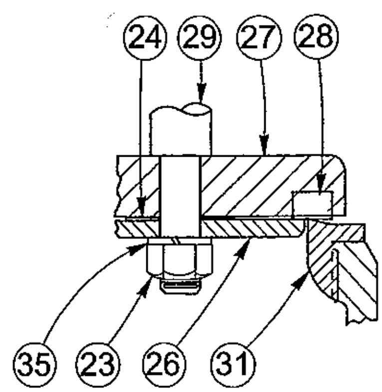
* RECOMMENDED SPARE PARTS

100-02 POWERTROL VALVE SIZES 1" - 3"

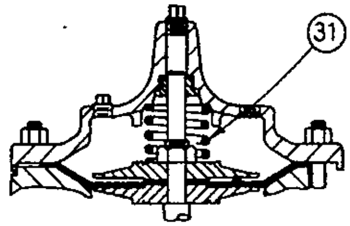




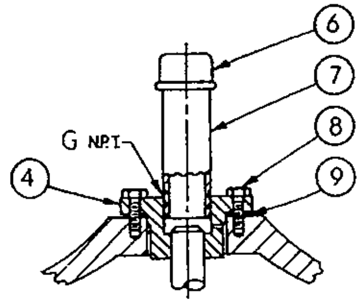
MODEL 100-02KH



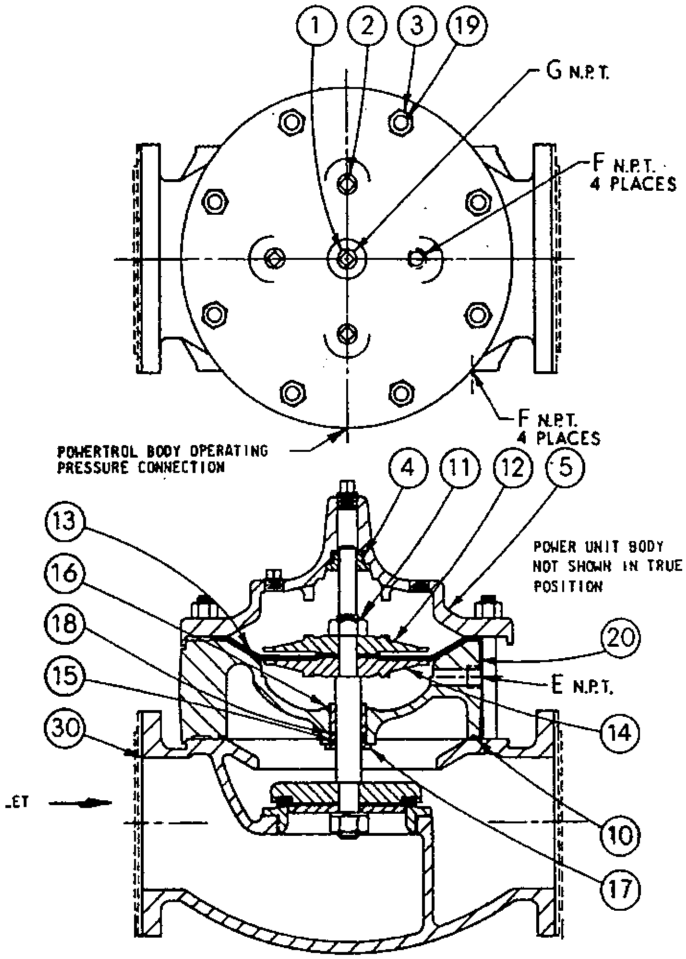
SEAT & DISC DETAILS



MODEL 100-02KH
4" - 14" SIZE

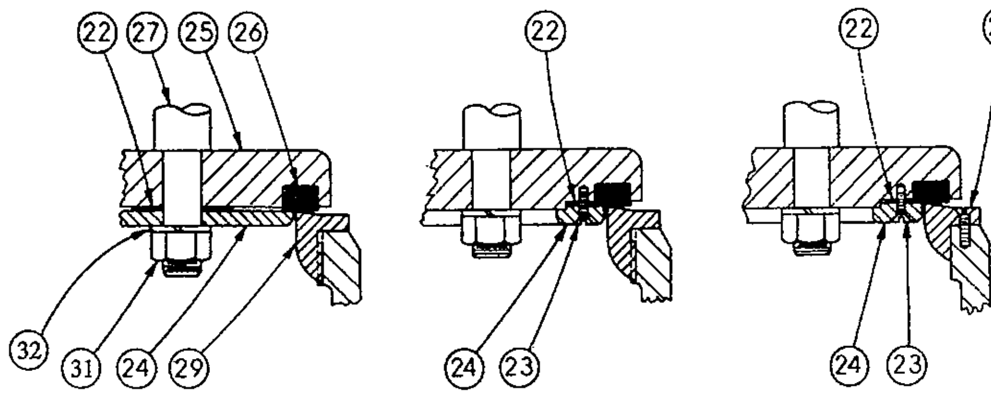


COVER BEARING
DETAIL
16" SIZE ONLY



PARTS

ITEM NO.	DESCRIPTION
1	CENTER COVER PLUG
2	COVER PLUG
3	STUD NUT
4	COVER BEARING
5	COVER
6	PIPE CAP (16" ONLY)
7	PIPE NIPPLE (16" ONLY)
8	COVER BEARING SCREW (16" ONLY)
9	COVER BEARING GASKET (16" ONLY)
10	GASKET "O" RING
11	UPPER STEM NUT
12	UPPER DIAPHRAGM WASHER
13	DIAPHRAGM
14	LOWER DIAPHRAGM WASHER
15	"O" RING
16	BEARING RETAINER RING
17	BEARING INSERT
18	"O" RING
19	STUD
20	POWER UNIT BODY
21	LOWER STEM NUT
22	SPACER WASHER
23	DISC GUIDE SCREW (6" - 16" ONLY)
24	DISC RETAINER
25	DISC
26	STEM
27	SEAT SCREW
28	SEAT
29	BODY
30	SPRING (USED ON MODELS 100-02KH
32	LOCK WASHER - SPRING



4" SIZE 6" SIZE 8-16" SIZE

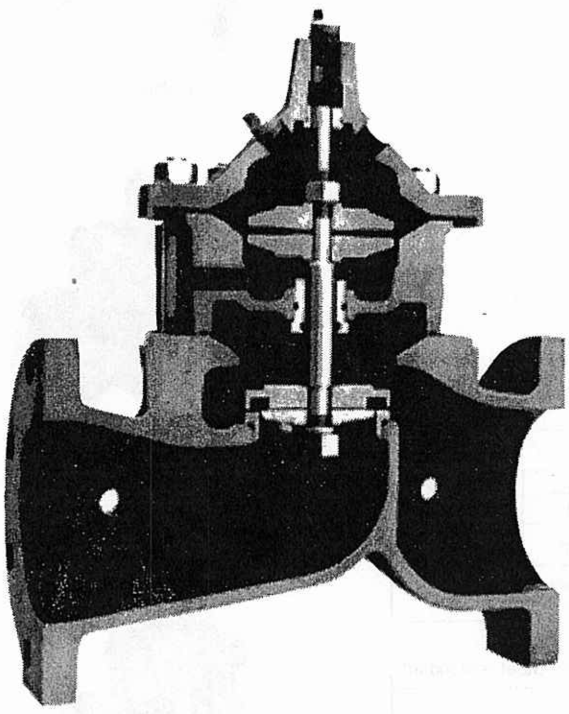
SEAT & DISC DETAIL

CLA-VAL

— MODEL — **100-21**

600 Series

Powertrol Valve



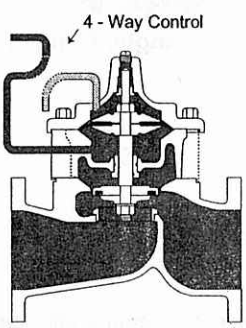
- **Reduced Cavitation Design**
- **Drip-tight, Positive Seating**
- **Service Without Removal From Line**
- **Globe or Angle Pattern**
- **Every Valve Factory-Tested**

The Cla-Val Model 100-21 is a hydraulically operated, diaphragm actuated, globe or angle pattern valve. It consists of four major components: the body, intermediate chamber, diaphragm assembly and cover. The diaphragm assembly is the only moving part.

The diaphragm assembly, which is guided top and center by a precision machined stem, utilizes a non-wicking diaphragm of nylon fabric bonded with synthetic rubber. The diaphragm forms a seal between the cover chamber and intermediate chamber. A synthetic rubber disc retained on three and one-half sides forms a drip-tight seal with the renewable seat when pressure is applied above the diaphragm. As pressure above the diaphragm is relieved and pressure is applied below the diaphragm, the valve opens wide for full flow. The rate of closing or opening can be controlled by modulating the pressure above or below the diaphragm.

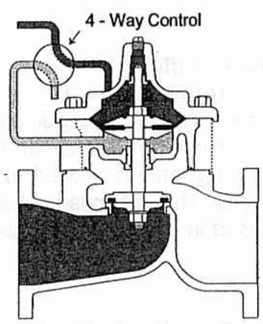
The Model 100-21 is recommended where independent operating pressure is desired. The valve's packless construction and simplicity of design assures a long life and dependable operation. Available in various materials and in a wide range of sizes. It's applications are many and varied.

Principle of Operation



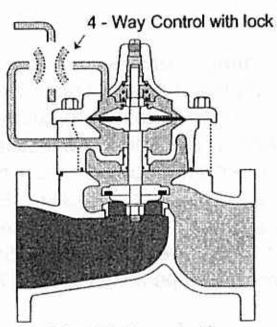
Full Open Operation

When operating pressure below the diaphragm is greater than the pressure in the cover chamber, the valve is held open, allowing full flow.



Tight Closing Operation

When pressure below the diaphragm is relieved and operating pressure is applied to the cover chamber, the valve closes drip-tight.



Modulating Action

The valve holds any intermediate position when operating pressure is equal above and below the diaphragm. A Cla-Val four-way pilot control with "lock" position can maintain this balance by stopping flow in the pilot control system.

CLA-VAL

Specifications

Available Sizes

Pattern	Flanged
Globe	3", 4", 6", 8", 10", 12", 14", 16", 18" 20", 24", 30"
Angle	4", 6", 8"

Operating Temp. Range

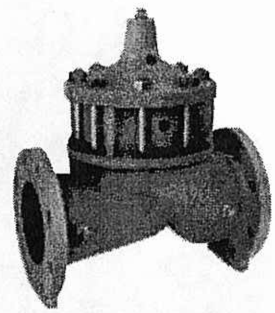
Fluids
-40° to 180° F


4" Globe, Flanged,

Pressure Ratings (Recommended Maximum Pressure - psi)

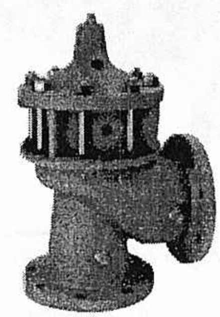
Valve Body & Cover		Pressure Class		
		Flanged		
Grade	Material	ANSI Standards*	150 lb.	300 lb.
ASTM A536	Ductile Iron	B16.42	250	400
ASTM A216-WCB	Cast Steel	B16.5	285	400
ASTM B62	Bronze	B16.24	225	400
ASTM A743	Stainless Steel	B16.5	285	400
356-T6	Aluminum	B16.1	275	—

Note: *ANSI standards are for flange dimensions only.
Flanged valves are available faced but not drilled.


6" Globe, Flanged

Materials

Component	Material Options				
Body & Cover	Ductile Iron	Cast Steel	Bronze	Stainless Steel	Aluminum
Available Sizes	3" - 30"	3" - 30"	3" - 16"	3" - 16"	3" - 16"
Disc Retainer & Diaphragm Washer	Cast Iron	Cast Steel	Bronze	Stainless Steel	Aluminum
Trim: Disc Guide, Seat & Cover Bearing	Bronze is standard. Stainless Steel is optional.			Stainless Steel is standard.	
Disc	Buna-N® Rubber				
Diaphragm	Nylon Reinforced Buna-N® Rubber				
Stem, Nut & Spring	Stainless Steel				


6" Angle, Flanged

Options

Epoxy Coating - suffix KC
An FDA approved fusion bonded epoxy coating for use with cast iron, ductile iron or steel valves. This coating is resistant to various water conditions, certain acids, chemicals, solvents and alkalies. Epoxy coatings are applied in accordance with AWWA coating specifications C550-90. Do not use with temperatures above 175°F.

Viton® Rubber Parts - suffix KB
Optional diaphragm, disc and o-ring fabricated with Viton® synthetic rubber. Viton® is well suited for use with mineral acids, salt solutions, chlorinated hydrocarbons, and petroleum oils; and is primarily used in high temperature applications up to 250° F. Do not use with epoxy coating above 175°F.

Heavy Spring - suffix KH
The heavy spring option is used in applications where there is low differential pressure across the valve, and the additional spring force is needed to help the valve close. This option is best suited for valves used in on-off (non-modulating) service.

Low Temperature Diaphragm - suffix KA
This single ply diaphragm uses Buna-N® Synthetic Rubber, formulated for low temperature applications to -65° F. Operating pressures in excess of 125 psi are not recommended.

For assistance in selecting appropriate valve options or valves manufactured with special design requirements, please contact our Regional Sales Office or Factory.

Valve Size		Inches	3	4	6	8	10	12	14	16	18	20	24	30
		mm.	80	100	150	200	250	300	350	400	460	510	610	760
C_V Factor	Globe Pattern	Gal./Min. (gpm.)	62	136	229	480	930	1458	1725	2110	2940	3400*	3500*	7900*
		Litres/Sec. (l/s.)	15	32.5	55	115	223	350	414	506	705	816	840	1895
	Angle Pattern	Gal./Min. (gpm.)	—	135	233	545	—	—	—	—	—	—	—	—
		Litres/Sec. (l/s.)	—	32	56	132	—	—	—	—	—	—	—	—
Equivalent Length of Pipe	Globe Pattern	Feet (ft.)	293	251	777	748	621	654	750	977	983	1125	3005	2130
		Meters (m.)	89.3	76.4	237.1	228.1	189.5	199.4	228.7	298.1	299.9	343.2	916.6	649.6
	Angle Pattern	Feet (ft.)	—	254	751	580	—	—	—	—	—	—	—	—
		Meters (m.)	—	77.6	229	176.9	—	—	—	—	—	—	—	—
K Factor	Globe Pattern		20.6	12.7	23.1	15.7	10.4	8.5	8.9	10.2	8.4	8.8	19.1	10.5
	Angle Pattern		—	12.9	22.3	12.2	—	—	—	—	—	—	—	—
Liquid Displaced from Diaphragm Chamber When Valve Opens		Fl. Oz	—	—	—	—	—	—	—	—	—	—	—	—
		U.S. Gal.	.032	.08	.17	.53	1.26	2.51	4	4	9.6	9.6	9.6	29.0
		ml	—	—	—	—	—	—	—	—	—	—	—	—
		Litres	.12	.30	.64	2.0	4.8	9.5	15.1	15.1	36.2	36.2	36.2	110

*Estimated

C_V Factor

Formulas for computing C_V Factor, Flow (Q) and Pressure Drop (ΔP):

$$C_V = \frac{Q}{\sqrt{\Delta P}} \qquad Q = C_V \sqrt{\Delta P} \qquad \Delta P = \left(\frac{Q}{C_V}\right)^2$$

K Factor (Resistance Coefficient)
The Value of K is calculated from the formula: $K = \frac{894 d^4}{C_V^2}$
(U.S. system units)

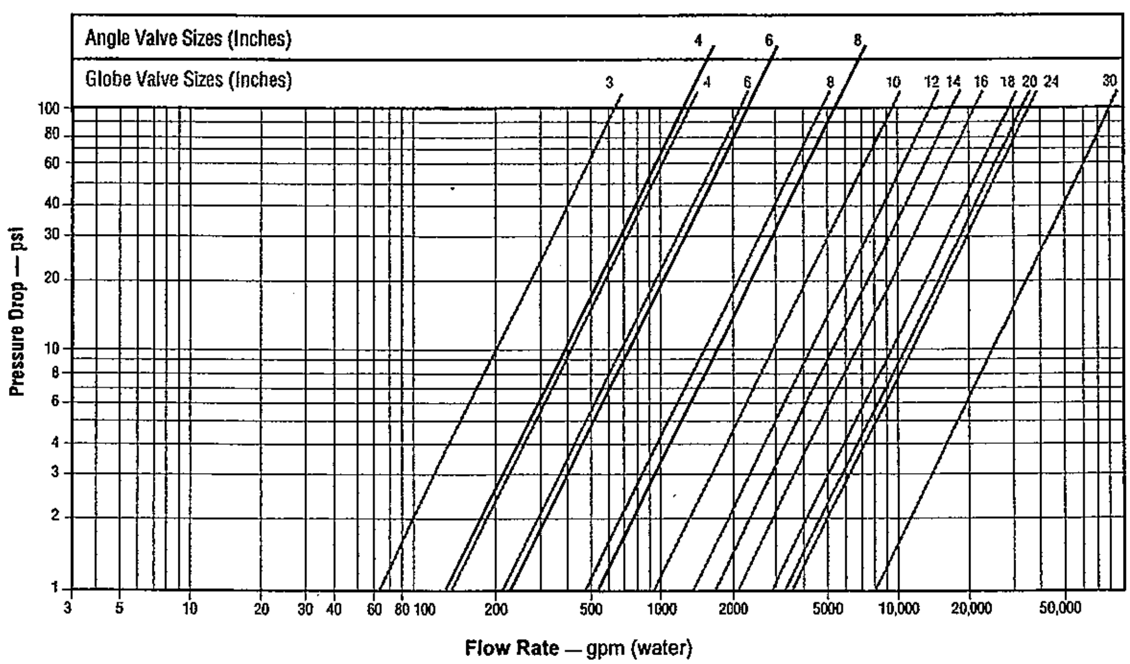
Equivalent Length of Pipe
Equivalent lengths of pipe (L) are determined from the formula: $L = \frac{Kd}{12f}$
(U.S. system units)

Fluid Velocity
Fluid velocity can be calculated from the following formula: $V = \frac{.4085\,Q}{d^2}$
(U.S. system units)

Where:

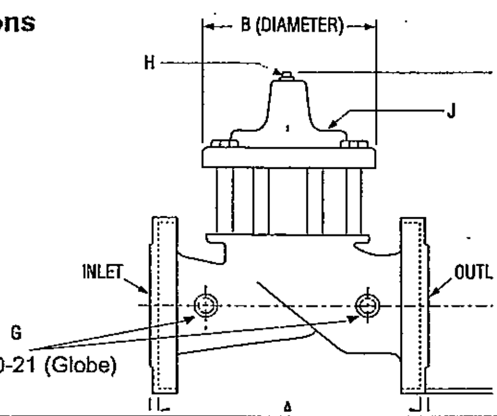
- C_V = U.S. (gpm) @ 1 psi differential at 60° F water
  or
  = (l/s) @ 1 bar (14.5 PSIG) differential at 15° C water
- **d** = inside pipe diameter of Schedule 40 Steel Pipe (inches)
- **f** = friction factor for clean, new Schedule 40 pipe (dimensionless) (from Cameron Hydraulic Data, 18th Edition)
- **K** = Resistance Coefficient (calculated)
- **L** = Equivalent Length of Pipe (feet)
- **Q** = Flow Rate in U.S. (gpm) or (l/s)
- **V** = Fluid Velocity (feet per second) or (meters per second)
- **ΔP** = Pressure Drop in (psi) or (bar)

Model 100-21 Flow Chart (Based on normal flow through a wide open valve)

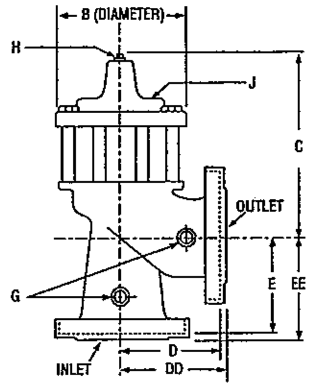


Dimensions

Model 100-21



100-21 (Globe)



100-21 (Angle)

VALVE SIZE (Inches)	**3**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**24**	**30**
A 150 ANSI	10.25	13.88	17.75	21.38	26.00	30.00	34.25	35.00	42.12	48.00	48.00	63.25
AA 300 ANSI	11.00	14.50	18.62	22.38	27.38	31.50	28.00	36.62	43.62	49.62	49.75	—
B DIA.	6.62	9.12	11.50	15.75	20.00	23.62	—	28.00	35.44	35.44	35.44	53.19
C MAX.	9.25	11.75	15.25	20.25	23.75	27.25	29.31	34.12	35.00	40.25	40.25	56.50
D 150 ANSI	—	6.94	8.88	10.69	—	—	—	—	—	—	—	—
DD 300 ANSI	—	7.25	9.38	11.19	—	—	—	—	—	—	—	—
E 150 ANSI	—	5.50	6.75	7.25	—	—	—	—	—	—	—	—
EE 300 ANSI	—	5.81	7.25	7.75	—	—	—	—	—	—	—	—
F 150 ANSI	3.75	4.50	5.50	6.75	8.00	9.50	11.00	11.75	15.88	14.56	17.00	19.88
FF 300 ANSI	4.12	5.00	6.25	7.50	8.75	10.25	—	12.75	15.88	16.06	19.00	—
G NPT Body Tapping	⅜	½	¾	¾	1	1	1	1	1	1	1	1
H NPT Cover Center Plug	½	½	¾	¾	1	1	1¼	1¼	2	2	2	2
J NPT Cover Tapping	⅜	½	¾	¾	1	1	1	1	1	1	1	1
Valve Stem Internal Thread UNF	10-32	¼-28	¼-28	⅜-24	⅜-24	⅜-24	⅜-24	⅜-24	½-20	½-20	½-20	¾-16
Stem Travel	0.6	0.8	1.1	1.7	2.3	2.8	3.4	3.4	3.4	4.5	4.5	6.5
Approx Ship Wt. Lbs.	70	135	230	480	785	1410	2215	2215	2300	3400	3600	7700

VALVE SIZE (mm)	**80**	**100**	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**	**600**	**750**
A 150 ANSI	260	353	451	543	660	762	870	889	1070	1219	1219	1607
AA 300 ANSI	279	368	473	568	695	800	—	930	1108	1260	1264	—
B DIA.	168	232	292	400	508	600	711	711	900	900	900	1351
C MAX.	235	298	387	514	603	692	744	867	889	1022	1022	1435
D 150 ANSI	—	176	226	272	—	—	—	—	—	—	—	—
DD 300 ANSI	—	184	238	284	—	—	—	—	—	—	—	—
E 150 ANSI	—	140	171	184	—	—	—	—	—	—	—	—
EE 300 ANSI	—	148	184	197	—	—	—	—	—	—	—	—
F 150 ANSI	95	114	140	171	203	241	279	298	403	370	432	505
FF 300 ANSI	105	127	159	191	222	260	—	324	403	408	483	—
G NPT Body Tapping	⅜	½	¾	¾	1	1	1	1	1	1	1	1
H NPT Cover Center Plug	½	½	¾	¾	1	1	1¼	1¼	2	2	2	2
J NPT Cover Tapping	⅜	½	¾	¾	1	1	1	1	1	1	1	1
Valve Stem Internal Thread UNF	10-32	¼-28	¼-28	⅜-24	⅜-24	⅜-24	⅜-24	⅜-24	½-20	½-20	½-20	¾-16
Stem Travel	15	20	28	43	58	71	86	86	86	114	114	165
Approx. Ship Wt. Kgs.	32	61	104	218	356	640	1006	1006	1044	1544	1634	3496

Service and Installation

Cla-Val Control Valves operate with maximum efficiency when mounted in horizontal piping with the main valve cover UP, however, other positions are acceptable. Due to component size and weight of 10 inch and larger valves, installation with cover UP is advisable. We recommend isolation valves be installed on inlet and outlet for maintenance. Adequate space above and around the valve for service personnel should be considered essential. A regular maintenance program should be established based on the specific application data. However, we recommend a thorough inspection be done at least once a year. Consult factory for specific recommendations.

CLA-VAL
PO Box 1325 Newport Beach CA 92659-0325
Phone: 949-722-4800 • Fax: 949-548-5441

CLA-VAL CANADA, LTD.
4687 Christie Drive
Beamsville, Ontario
Canada L0R 1B4
Phone: 905-563-4963
Fax: 905-563-4040

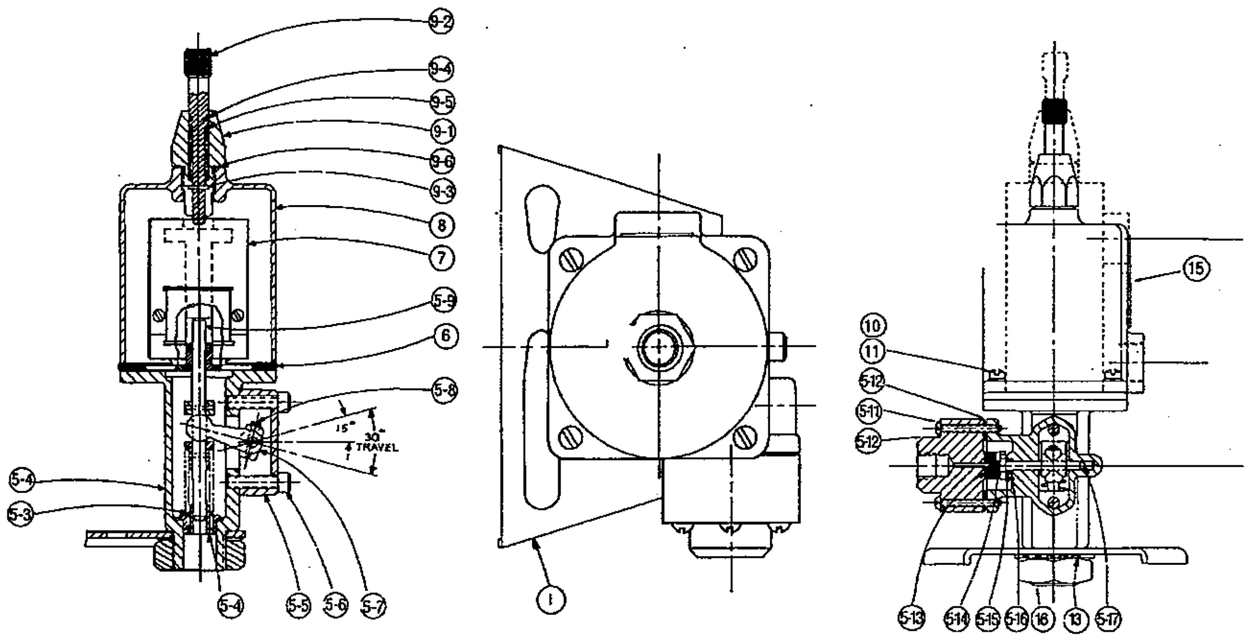
CLA-VAL SA
Chemin des Mesanges 1
CH-1032 Romanel/
Lausanne, Switzerland
Phone: 41-21-643-15-55
Fax: 41-21-643-15-50
www.cla-val.com

Represented By:

CLA-VAL™

CSM-11

Solenoid Control



ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	Mounting Bracket	7	Solenoid Assy. (See table other side)
5	Mechinal Parts Assy.		
5-2	Housing	8	Cover (A.C. only)
5-3	Spring	9	Manual operator assy
5-4	Guide	9-1	Housing, Manual Operator
5-5	Side Housing	9-2	Plunger
5-6	Cap Screw 1/4'	9-3	Pin, groove-3/8"
5-7	Lever Arm	9-4	"O"- Ring
5-8	Lever Screw	9-5	Spring, Manual Operator
5-9	Stem assy. (Solenoid)	9-6	Gasket, Manual Operator
5-10	Distributor Gasket	10	Machine Screw Fil. Hd.
5-11	Machine Screw, RDH (6/32 x 1 1/4 - 6 reqd.)		(A.C. Only 10/32 x 5/8-4 reqd.) (4 reqd.)
5-12	Distributor (CSM11-A2-2)	11	Lockwasher
5-13	Disc Assy.	12	Machine Screw Fil. Hd. (D.C. Only) 10/32 x 7/16 (4 required)
5-14	Spring (Disc Assy.)		
5-15	Thrust Washer	13	Lockwasher
5-16	"O"- Ring	14	Coil only: (See table other side)
5-17	Stem Assy. (Pilot)	15	Nameplate
6	Spacer Gasket (A.C. only)	16	Hex Nut, Jam 1-14 UNS

When ordering parts, please specify:

- All Nameplate Data
- Item Number
- Description
- Material
- Recommended Spare Parts

CSMII CONTROL ASSEMBLY						SOLENOID ASSEMBLY & COILS			
	CSMII-A2-2		CSMII-N2-4	CSMII-CZ2-4	CSMII-CQ2-4	NOTE: Cover, solenoid and coil of the D.C. model is supplied as a complete unit and is not sold separately. For all other parts see other side.			
	STANDARD	SEA-WATER SERVICE	STANDARD	STANDARD	STANDARD			AMPS	
VOLTAGE	STOCK No.	STOCK No.	STOCK No.	STOCK No.	STOCK No.	SOLENOID PART No.	COIL PART No.	HOLDING	INRUSH
24/60 Hz	10023-01J	—	10031-01B	10039-01E	10038-01G	87573-01A	73342J	2.98	25.4
115/60 Hz	10023-02G	10046-01K	10031-02K	10039-02C	10038-02E	—	—	—	—
120/60 Hz	10023-02G	10046-01K	10031-02K	10039-02C	10038-02E	87573-02J	73343G	.575	5.1
208/60 Hz	10023-03E	—	10031-03H	10039-03A	10038-03C	87573-03G	73344E	.33	2.93
230/60 Hz	10023-04C	—	10031-04F	10039-04J	—	—	—	—	—
240/60 Hz	10023-04C	—	10031-04F	10039-04J	10038-04A	87573-04E	73345B	.288	2.54
440/60 Hz	10023-09B	—	10031-09E	10039-09H	10038-09K	87573-09D	82542C	.156	1.38
460/60 Hz	10023-05K	—	10031-05C	10039-05F	—	—	—	—	—
480/60 Hz	10023-05K	—	10031-05C	10039-05F	10038-05H	87573-05B	73346K	.143	1.27
110/50 Hz	10023-06H	—	10031-06A	10039-06D	10038-06K	87573-06K	73347H	.48	4.6
220/50 Hz	10023-07F	—	10031-07J	10039-07B	10038-07D	87573-07H	73348F	.24	2.3
240/50 Hz	10023-08D	—	10031-08G	10039-08K	10038-08B	87573-08F	73349D	.22	2.1
12 VDC	10024-01G	10045-01B	—	10040-01C	—	98297-01D		1.0	40.0
24 VDC	10024-02E	10045-02K	—	10040-02A	—	98297-02B		.603	24.0
28 VDC	10024-03C	—	—	10040-03J	—	98297-03K		.629	15.6
32 VDC	10024-04A	—	—	10040-04G	—	98297-04H		.500	18.6
48 VDC	10024-05H	—	—	10040-05D	—	98297-05E		.293	10.8
115 VDC	10024-06F	—	—	10040-06B	—	98297-06C		.122	4.42
125 VDC	10024-07D	—	—	10040-07K	—	98297-07A		.119	4.44
250 VDC	10024-08B	—	—	10040-08H	—	98297-08J		.072	2.45

CVCL 1 ② 3 4 DIST CODE 007A SHEET 1 OF 1

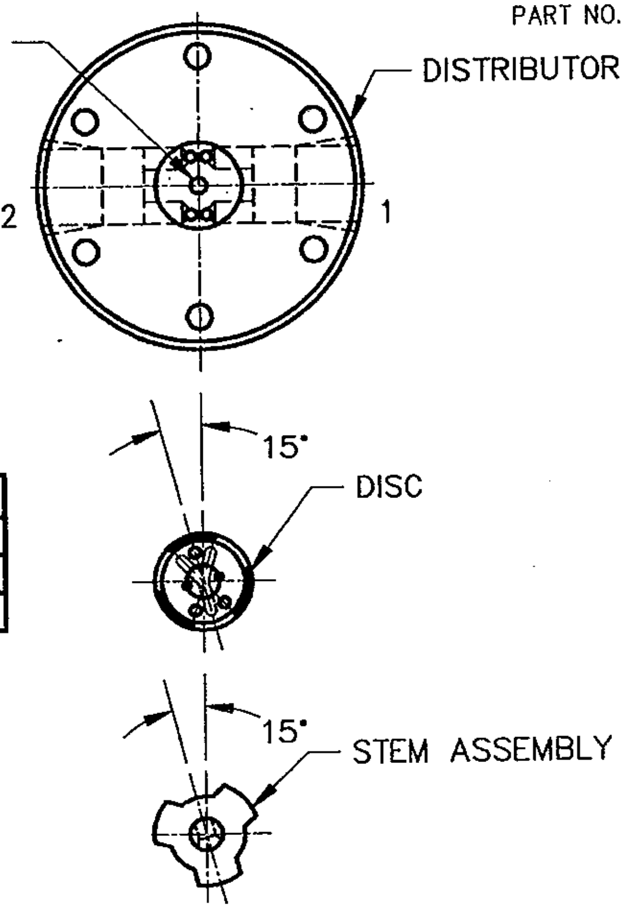
CLA-VAL CO. NEWPORT BEACH, CALIFORNIA	CATALOG NO. CSM11-A2-2	DRAWING NO. 73312	REV D

TYPE OF VALVE AND MAIN FEATURES

STACK-UP
CSM11-A2-2

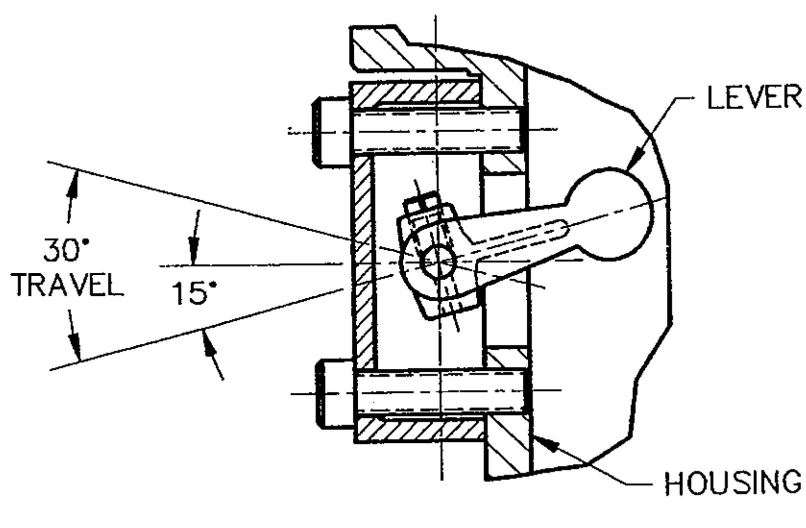
DESIGN		
DRAWN	WEP	3-10-81
CHK'D	KD	3-18-81
APV'D	CH	4-2-81

PART NO. 73312-01K



OPERATION		
PORTS	1	2
DE-ENERGIZED	D	S
ENERGIZED	S	D

S = SUPPLY
D = DRAIN



CAD REVISION RECORD - DO NOT REVISE MANUALLY

LTR	DESCRIPTION	BY	DATE
A-C	SEE REVISION FILE		
D	REDRAWN ON CAD; CHANGED DISC ASSEMBLY TO DISC (NED 44640)	AK	10-05-99

CLA-VAL

—MODEL— **CV**

Flow Control

DESCRIPTION

The Cla-Val Model CV Flow Control is a simply-designed, spring-loaded check valve. Rate of flow is full flow in one direction and restricted in other direction. Flow is adjustable in the restricted direction. It is intended for use in conjunction with a pilot control system on a Cla-Val Automatic Control Valve.

OPERATION

The CV Flow Control permits full flow from port A to B, and restricted flow in the reverse direction. Flow from port A to B lifts the disc from seat, permitting full flow. Flow in the reverse direction seats the disc, causing fluid to pass through the clearance between the stem and the disc. This clearance can be increased, thereby increasing the restricted flow, by screwing the stem out, or counter-clockwise. Turning the stem in, or clockwise reduces the clearance between the stem and the disc, thereby reducing the restricted flow.'

INSTALLATION

Install the CV Flow Control as shown in the valve schematic All connections must be tight to prevent leakage.

DISASSEMBLY

Follow the sequence of the item numbers assigned to the parts in the cross sectional illustration for recommended order of disassembly.

Use a scriber, or similar sharp-pointed tool to remove O-ring from the stem.

INSPECTION

Inspect all threads for damage or evidence of cross-threading. Check mating surface of seat and valve disc for excessive scoring or embedded foreign particles. Check spring for visible distortion, cracks and breaks. Inspect all parts for damage, corrosion and cleanliness.

CLEANING

After disassembly and inspection, cleaning of the parts can begin. Water service usually will produce mineral or lime deposits on metal parts in contact with water. These deposits can be cleaned by dipping the parts in a 5-percent muriatic acid solution just long enough for deposits to dissolve. This will remove most of the common types of deposits. **Caution: use extreme care when handling acid.** If the deposit is not removed by acid, then a fine grit (400) wet or dry sandpaper can be used with water. Rinse parts in water before handling. An appropriate solvent can clean parts used in fueling service. Dry with compressed air or a clean, lint-free cloth. Protect from damage and dust until reassembled.

REPAIR AND REPLACEMENT

Minor nicks and scratches may be polished out using a fine grade of emery or crocus cloth; replace parts if scratches cannot be removed.

Replace O-ring packing and gasket each time CV Flow Control is overhauled.

Replace all parts which are defective. Replace any parts which create the slightest doubt that they will not afford completely satisfactory operation. Use Inspection steps as a guide.

REASSEMBLY

Reassembly is the reverse of disassembly; no special tools are required.

TEST PROCEDURE

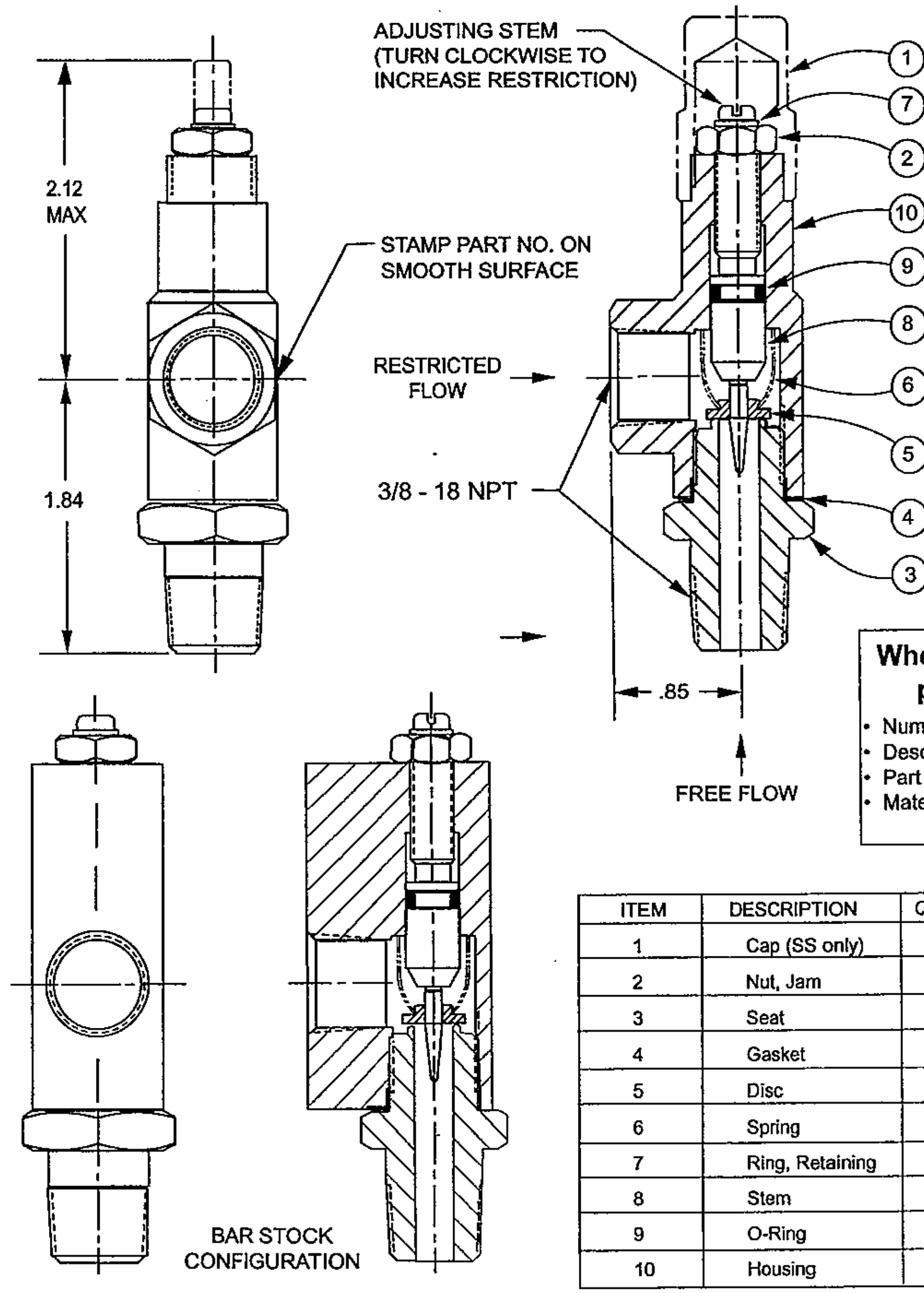
No testing of the flow Control is required prior to reassembly to the pilot control system on Cla-Val Main Valve.

CLA-VAL P.O. Box 1325 • Newport Beach, CA 92659-0325 • Phone: 949-722-4800 • Fax: 949-548-5441 • E-mail: claval@cla-val.com • Website cla-val.com

CLA-VAL

CV

3/8" Flow Control



When ordering parts, please specify:

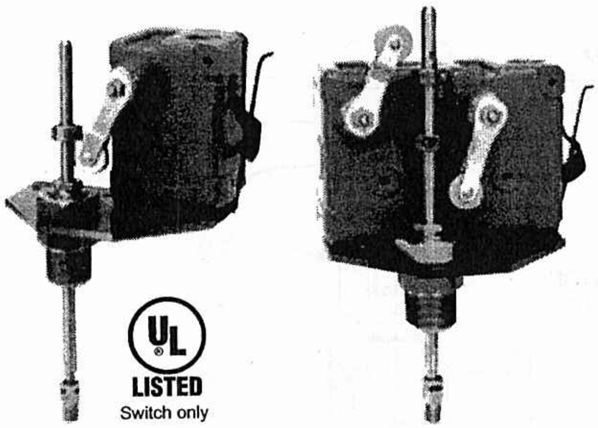
- Number Stamped on Side
- Description (CV Flow Control)
- Part Description
- Material

ITEM	DESCRIPTION	QUAN.
1	Cap (SS only)	1
2	Nut, Jam	1
3	Seat	1
4	Gasket	1
5	Disc	1
6	Spring	1
7	Ring, Retaining	1
8	Stem	1
9	O-Ring	1
10	Housing	1

CLA-VAL

MODEL X105L X105L2

Limit Switch Assemblies

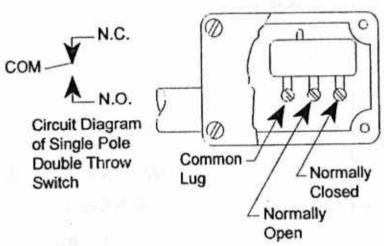


- **UL Listed Switches**
- **Positive Action**
- **Rugged and Dependable**
- **Weather Proof or Explosion Proof**
- **Easy To Adjust**

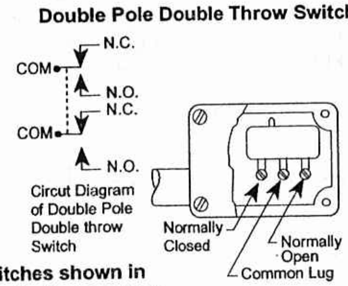
The Cla-Val Model X105L/X105L2 Limit Switch Assembly is a rugged, dependable and positive acting switch assembly actuated by the opening or closing of a Cla-Val control valve on which it is mounted. The single pole, double throw micro switch can be connected either to open or to close an electrical circuit when actuated. By loosening the allen screw on the actuating collar and raising or lowering the collar on the stem, the X105L is easily adjusted to signal that the valve has fully reached the desired position (open or closed).

Installation

Single Pole Double Throw Switch



Double Pole Double Throw Switch

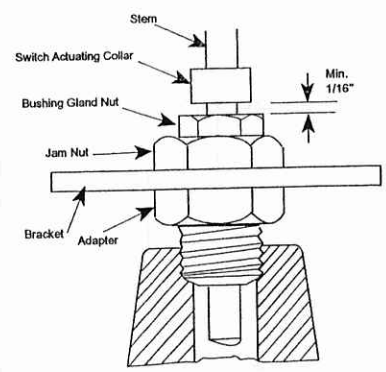


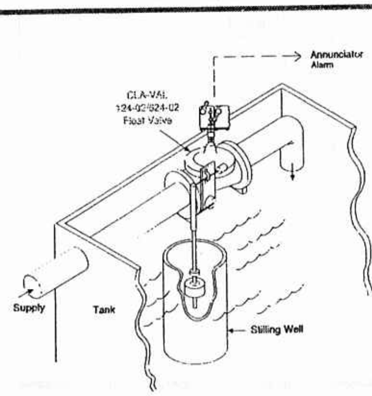
Switches shown in unactivated position.

1. Remove plug in top of valve cover.
2. Screw actuating stem into main valve stem.
3. Slip adapter down over stem and screw into place on valve cover.
4. Attach micro switch housing and bracket to adapter with jam nut.
5. Bring electrical supply circuit into unit through the 1/2" tapping in micro switch housing.
6. Adjust switch collars. (Set collar to trip switch after valve is positioned fully open or fully closed)

Actuating Collar Adjustment Minimum Setting

When adjusting actuating collar for proper switch action, a clearance of at least 1/16" (1/8" for 24" valve) must be provided between the collar and the bushing gland nut when valve is in the fully closed position.



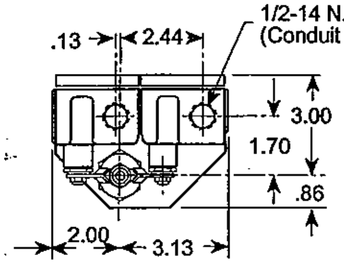


Annunciator Alarm

Typical Application

Used for any electrical operation which can be performed by either opening or closing a switch; such as alarm systems, process control, pump control, motor starting or stopping, etc. Readily attached to most Cla-Val Valves.

Dimensions (In Inches)



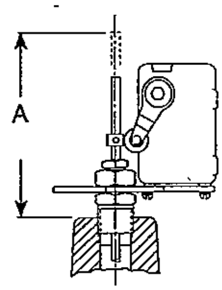


Fig. 2
Valve Size
1 1/4" Thru 24"
X105LCW
X105LCX

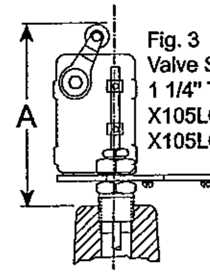


Fig. 3
Valve Size
1 1/4" Thru 8"
X105LOW
X105LOX

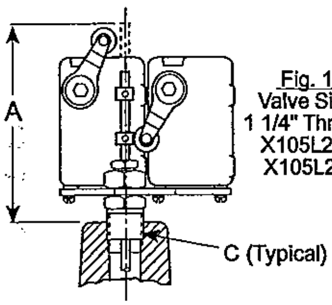


Fig. 1
Valve Size
1 1/4" Thru 8"
X105L2W
X105L2X

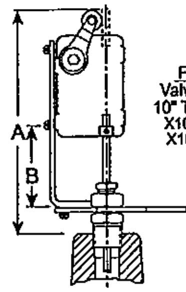


Fig. 4
Valve Size
10" Thru 24"
X105LOW
X105LOX

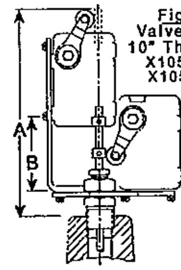


Fig. 5
Valve Size
10" Thru 24"
X105L2W
X105L2X

VALVE SIZE	11/4" & 11/2"	2" & 21/2"	3"	4"	6"	8"	10"	12"	14"	16"	20"	24"
Dim "A"	10.19	7.16	7.34	7.00	6.69	6.91	9.88	9.59	9.16	10.78	10.78	10.78
Dim "B"						1.69	2.44	2.94	2.94	2.94	2.94	2.94
C (NPT)	1/4	1/2	1/2	3/4	3/4	1	1	11/4	11/2	2	2	2

Specifications

Materials: Aluminum switch housing
Steel bracket and brass adapter
Stainless steel stem

Electrical: 1/2" Conduit connection

Switch Type: SPDT UL, File No. E12252,
CSA Certified, File No. LR57325
Weather proof
NEMA 1,3,4, and13

Switch Rating: UL/CSA rating: L96
15 amp. 125, 250, or 480 volts AC
1/2 amp. 125 volts DC
1/4 amp. 250 volts DC

Switch Options: DPDT switches available on request
UL/CSA Rating: L59, 10 amps

Explosion proof micro switches are NEMA 1,7, and 9
UL Listed, File No. E14274 and CSA Certified, File No. LR57324: Class I, Group C and D and Class II, Group E, F and G.

When Ordering, Please Specify

1. Valve Size
2. Catalog Number from Table Below
3. All Valve Name Plate Data
4. Select Single or Double Pole Switch
5. Explosion Proof or Weather Proof Type Enclosure
6. Amperes and Voltage, AC or DC
7. Actuating Position (Valve Open or Closed)

CATALOG NO.	ACTUATION POSITION	SWITCH ENCLOSURE
X105LCW	Valve Closed	Weather Proof
X105LCX	Valve Closed	Explosion Proof
X105LOW	Valve Open	Weather Proof
X105LOX	Valve Open	Explosion Proof
X105L2W	Dual	Weather Proof
X105L2X	Dual	Explosion Proof

CLA-VAL
PO Box 1325 Newport Beach CA 92659-0325
Phone: 949-722-4800 • Fax: 949-548-5441

CLA-VAL CANADA, LTD.
4687 Christie Drive
Beamsville, Ontario
Canada L0R 1B4
Phone: 905-563-4963
Fax: 905-563-4040

CLA-VAL SA
Chemin des Mesanges 1
CH-1032 Romanel/
Lausanne, Switzerland
Phone: 41-21-643-15-55
Fax: 41-21-643-15-50
www.cla-val.com

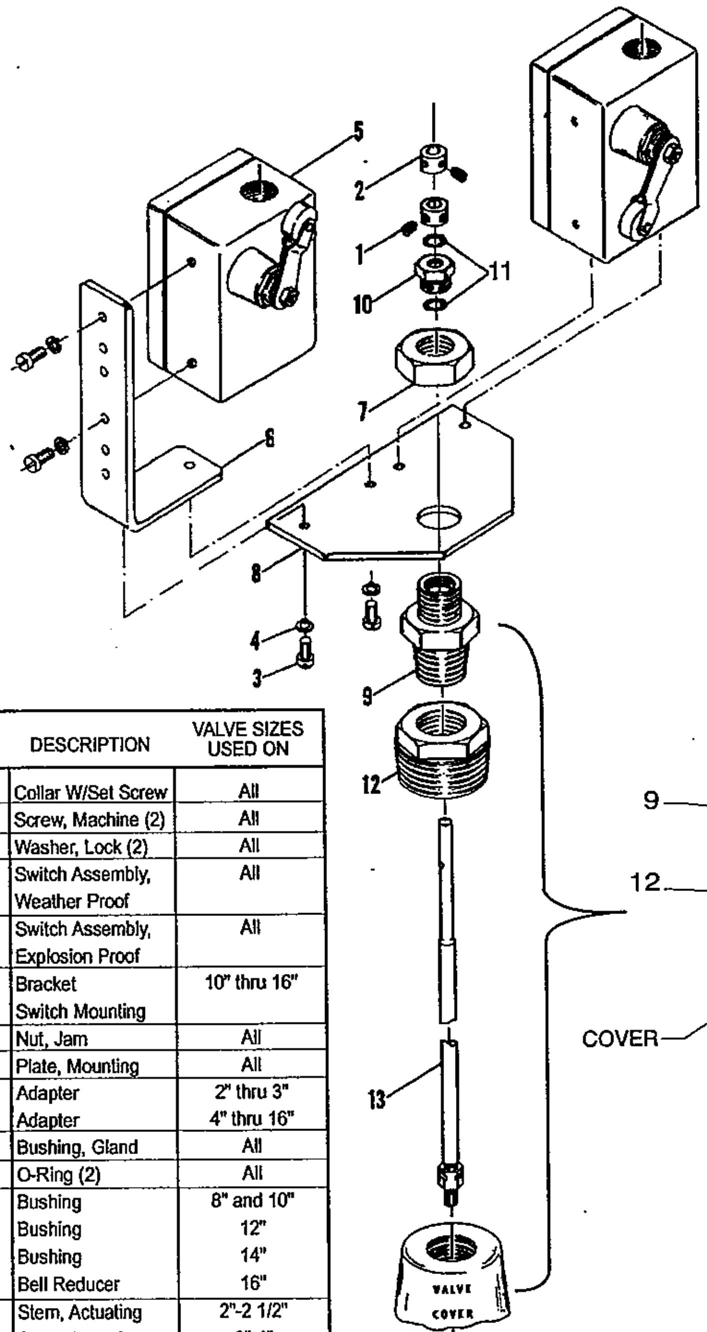
Represented By:

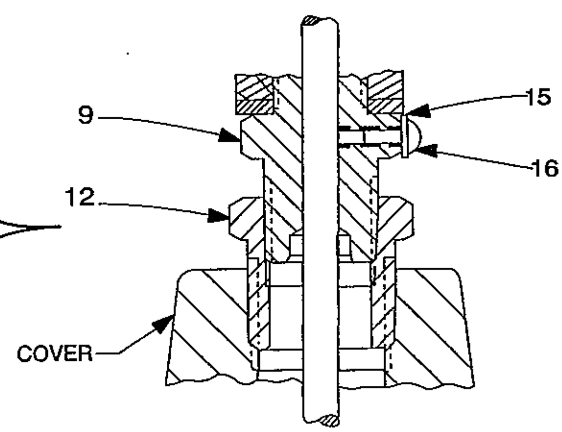
PARTS LIST

X105L

Limit Switch Assembly

CLA-VAL





ITEM	PART NUMBER	DESCRIPTION	VALVE SIZES USED ON
1-2	80047-01C	Collar W/Set Screw	All
3	67578-21B	Screw, Machine (2)	All
4	67584-23F	Washer, Lock (2)	All
5	34637K	Switch Assembly, Weather Proof	All
	34633J	Switch Assembly, Explosion Proof	All
6	64310G	Bracket Switch Mounting	10" thru 16"
7	67815-06J	Nut, Jam	All
8	63674G	Plate, Mounting	All
9	2838201J 2838202G	Adapter Adapter	2" thru 3" 4" thru 16"
10	63398C	Bushing, Gland	All
11	00951E	O-Ring (2)	All
12	67644-17K 67644-18H 67644-19F 67656-91J	Bushing Bushing Bushing Bell Reducer	8" and 10" 12" 14" 16"
13	89701-01F 89701-02D 89701-03B 89701-04K 89701-05G	Stem, Actuating Stem, Actuating Stem, Actuating Stem, Actuating Stem, Actuating	2"-2 1/2" 3"-4" 6"-8" 10"-12"-14" 16"
15	6551201H	Fiber Wshr	All
16	6824421K	Screw 8-32 x 3/8	All

When ordering parts, please specify:

- Item Number
- Description
- Part Number

CVCL 1 ② 3 4 DIST CODE 049 SHEET 1 OF 2

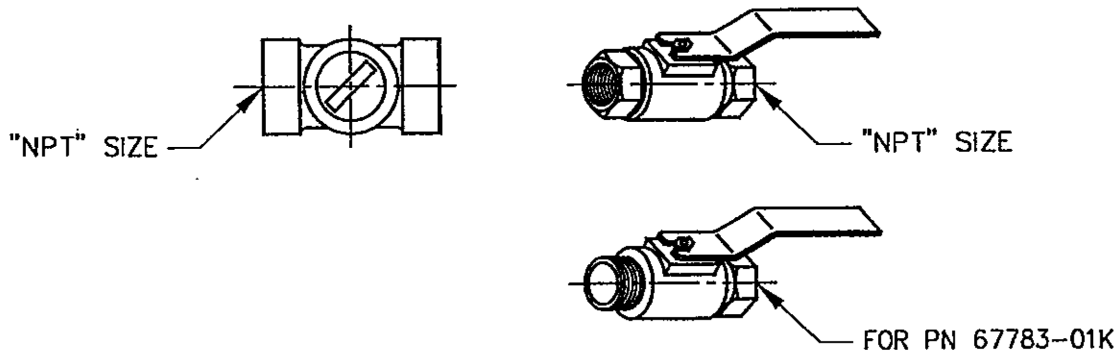
CLA-VAL CO. NEWPORT BEACH, CALIFORNIA	CATALOG NO.	DRAWING NO. 67783	REV AS

TYPE OF VALVE AND MAIN FEATURES

CK2 COCK/BALL VALVE

DESIGN		
DRAWN	MGR	4-02-80
CHK'D	KD	4-03-80
APV'D	CH	4-07-80

SCALE: NONE



CLA-VAL PART NO. AND MATERIAL

BRONZE WITH HANDLE	STEEL WITH HANDLE	IRON WITH HANDLE	316 SST WITH HANDLE	316 SST W/ LOCKING HANDLE	BRONZE WITH HANDLE	MONEL WITH HANDLE	SIZE "NPT"
67783-01K*	-09C	-17F	-25J SUPSD BY-26G		-41F SUPSD BY-01K		1/8"
-02H	-10A	-18D	-26G	-51E SUPSD BY-26G -52C	-42D SUPSD BY-02H		1/4"
-03F*	-11J	-19B	-27E	-46E SUPSD BY-27E -53A	-45G	-48A SUPSD BY-49J	3/8"
-04D	-12G	-20K	-28C	-54J	-43B SUPSD BY-04D	-49J	1/2"
-05A	-13E	-21H	-29A		-44K SUPSD BY-05A		3/4"
-06J	-14C	-22F	-30J				1"
-07G	-15K	-23D	-31G				1 1/4"
-08E	-16H	-24B	-32E				1 1/2"
-50G			-47C				2"

* SEE ENGINEERING APPROVED VENDORS TABLE (SHEET 2 OF 2).

AK	03-07-01	ADDED "*" TO PN. 67783-01K TO SH. 1 (ECO 18551)	

CAD REVISION RECORD - DO NOT REVISE MANUALLY

LTR	DESCRIPTION	BY	DATE
A-AR	SEE REVISION FILE		
AS	ADDED ANDERSON BRASS 1/8 FPT X 1/8 MPT TO SHEET 2 AND		

CLA-VAL

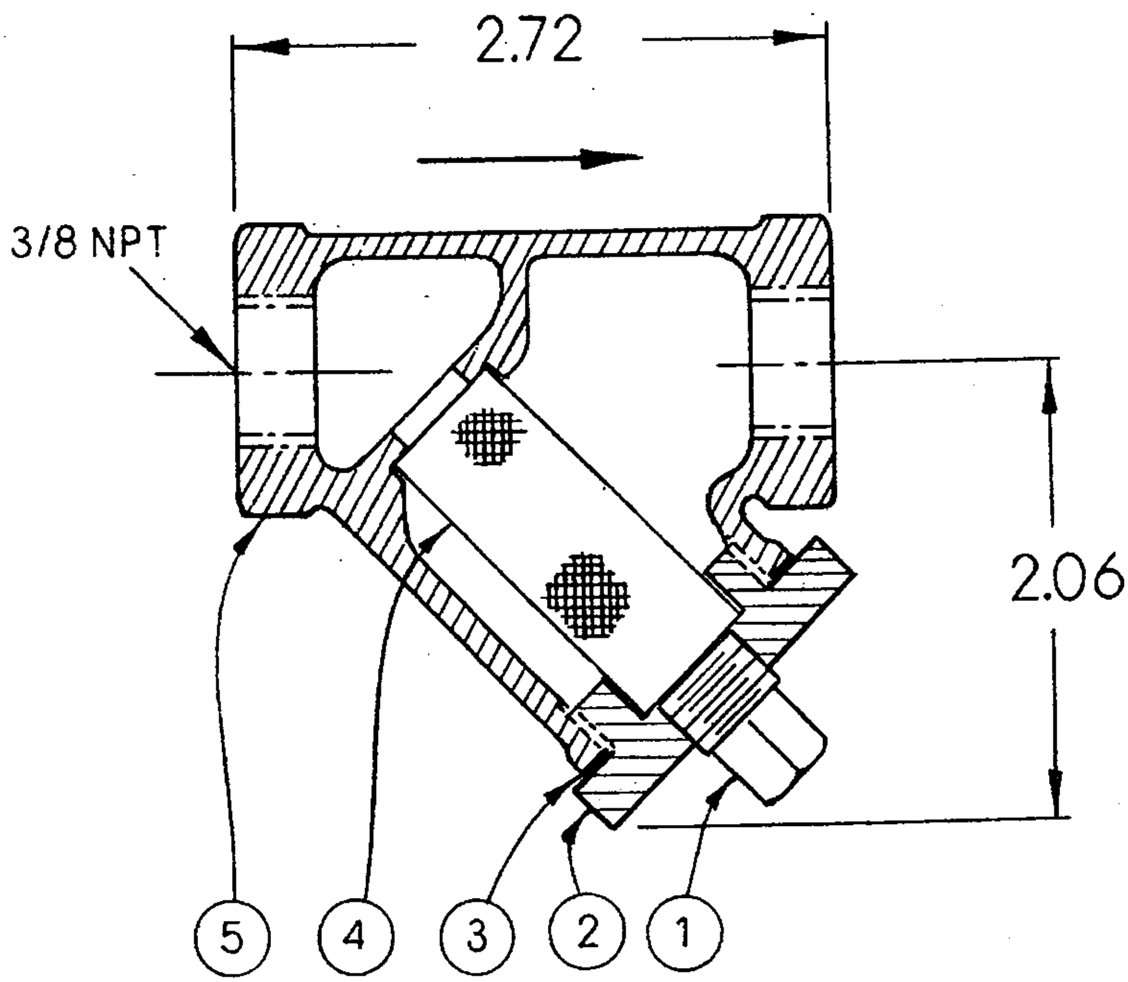
X43
Strainer

ITEM	DESCRIPTION	MATERIAL
1	Pipe Plug	Steel
2	Strainer Plug	Brass
3	Gasket	Copper
4*	Screen	Monel
5	Body	Brass

*Replacement screen stock number 68373A.
All other parts available only in replacement assembly.

Standard 60 mesh pilot system strainer for fluid service.

SIZE	STOCK NUMBER
3/8 x 3/8	33450J

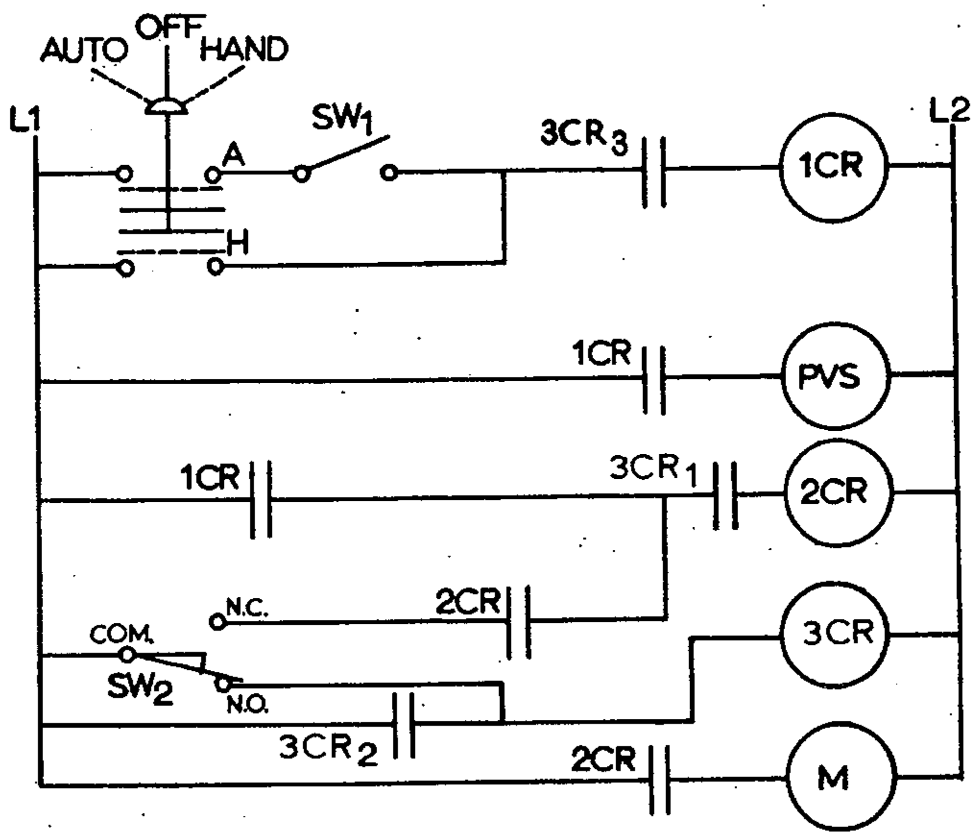


CLA-VAL CO. NEWPORT BEACH, CALIFORNIA

CATALOG NO.	DRAWING NO.	REV.
60 SERIES	69548	D

SUGGESTED WIRING DIAGRAM FOR 60 SERIES PUMP CONTROL VALVE WITH PUMP IN "OFF" POSITION

DESIGN		
DRAWN	B.F.	10-20-67
CHK'D.	JM	10-21-67
APP'D.	HWE	10-21-67
SCALE	DIST. CODE 002	



AUTO-OFF-HAND	= SELECTOR SWITCH
1CR	= RELAY, DPST NORMALLY OPEN
2CR	= RELAY, DPST NORMALLY OPEN
3CR	= RELAY, TPST NORMALLY OPEN
SW_1	= SWITCH, REMOTE START, AUTOMATIC
SW_2	= SWITCH, SPDT, VALVE LIMIT SWITCH
PVS	= PILOT VALVE SOLENOID
M	= PUMP MOTOR STARTER

NOTE: SW_2 AND PVS SUPPLIED BY CLA-VAL CO. ALL OTHER ELECTRICAL ITEMS SUPPLIED BY CUSTOMER. SW_2 IS INCLUDED IN THE X105L SWITCH ASSEMBLY WHICH IS MOUNTED ON THE PUMP CONTROL VALVE COVER.

REVISION RECORD

LTR	DESCRIPTION	BY	DATE
A	ADD RELAY 3CR & REVISED TITLE	CH	10-12-76
B	SEE ECO 23604	JA	9-30-77
C	REINSTATED, ECO 26185	JH	11-7-78
D	COLUMN SW_2 REMOVED "CONNECT TO N.C. TERMINAL" (ECO 5628)	BH	12-28-83

69548

61 Series
Deep Well Pump Control Valves - Electrical Controls

Note:
Please refer to Cla-Val drawing #69548, the Product Data Catalog and the Installation, Operation, & Maintenance Manual shipped with the Control Valve.

Start Up Procedure

The limit switch (SW2) on the valve should be adjusted before the pump control valve is placed in service. The stop collar on the limit switch stem should be adjusted to strike the switch arm roller as the valve travels open to the 95% (approx.) closed position. The N.O. contacts on the SW2 limit switch will close when the adjustable collar strikes the limit switch roller and moves the switch arm.

Please read the operating instructions carefully. Make all adjustments (opening speed control, closing speed control and limit switch) before starting the well pump or turning on the electrical control power.

After the above adjustments have been made the H-O-A switch should be placed in the "off" position and the electrical control power should be turned on. The 61 Series control valve should then be permitted to open (please see manual) and allow the limit switch (SW2) stop collar to contact the SW2 switch roller. This action closes the N.O. contacts on SW2 and energizes the coil on relay 3CR.

The H-O-A switch can now be placed in the "automatic" position and the following operation should result:

Pump Starting - Pump Running Cycle

There are two ways in which the pump motor (M) starting cycle may be "called" on:

1 - The pump motor may be "called" on by manually placing the H-O-A switch in the hand position. This action bypasses the automatic remote switch (SW1) and calls the pump on.

2 - The pump motor may be "called" on by manually placing the H-O-A switch in the "automatic" position provided that the automatic switch (SW1) contacts close. This action places the pump motor under the command of SW1 and the associated safety controls. The pump motor (M) can not be called on, under any conditions, if the H-O-A switch is manually placed in the "off" position.

When SW1 contacts close (assuming that 3CR coil is energized—see start up procedure above) coil 1CR is energized, both contacts 1CR close to energize pilot valve solenoid (PVS) and relay coil 2CR. Both contacts 2CR close and the pump motor (M) starts immediately as the valve begins to close. As the limit switch SW2 stem collar drops off the roller, SW2 contacts N.C., close. The pump is now locked on the line by SW2 and the valve slowly continues to go completely closed, directing all liquid flow to the pipeline.

Power Failure (While Pump Is Running) Conditions

If a momentary power failure should occur while the pump is running, relay coil 3CR would be de-energized and contacts $3CR_1$, $3CR_2$, and $3CR_3$ would open. This action would completely lock the pump motor out from restarting and keep the valve solenoid PVS de-energized until the valve opens to the set point of SW2 limit switch. Thus, even though the power is restored immediately following the power failure the pump cannot restart until the system is "ready", hydraulically, for a new start up.

Pump Stopping - Pump Off Conditions

When SW1 contacts are opened, or the H-O-A switch is manually placed in the off position, coil 1CR contacts open and the PVS coil is de-energized. Since the SW2 contacts are in the normally closed position the pump motor (M) continues to run as the pump control valve slowly opens. When the SW2 stop collar reaches the roller arm, the SW2 N.C. contacts will open, 2CR coil will be de-energized, both 2CR contacts will open and the pump motor (M) will stop. The pump motor will remain off under these conditions. Coil 3CR will remain energized and contacts $3CR_1$, $3CR_2$, and $3CR_3$ will remain closed. The Cla-Val 61 Series will remain open under these conditions.

Cla-Val Product Identification

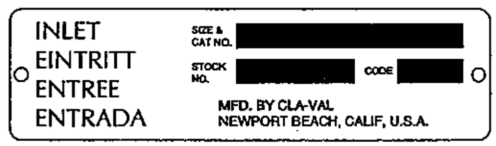
How to Order

Proper Identification

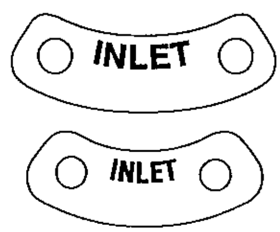
For ordering repair kits, replacement parts, or for inquiries concerning valve operation it is important to properly identify Cla-Val products already in service. Include all nameplate data with your inquiry. Pertinent product data includes valve function, size, material, pressure rating, end details, type of pilot controls used and control adjustment ranges.

Identification Plates

For product identification, cast in body markings are supplemented by identification plates as illustrated on this page. The plates, depending on type and size of product, are mounted in the most practical position. **It is extremely important that these identification plates are not painted over, removed, or in any other way rendered illegible.**

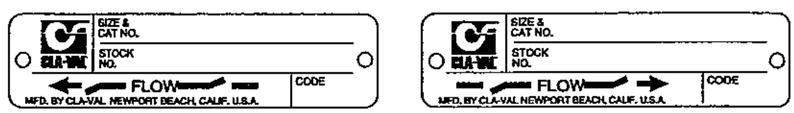


This brass plate appears on valves sized 2½" and larger and is located on the top of the inlet flange.

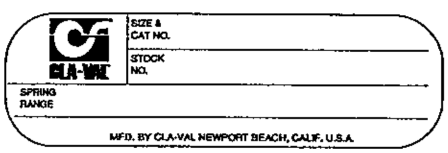


These two brass plates appear on ⅜", ½", and ¾" size valves and are located on the valve cover.

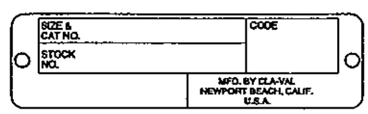
This brass plate appears on altitude valves only and is found on top of the outlet flange.



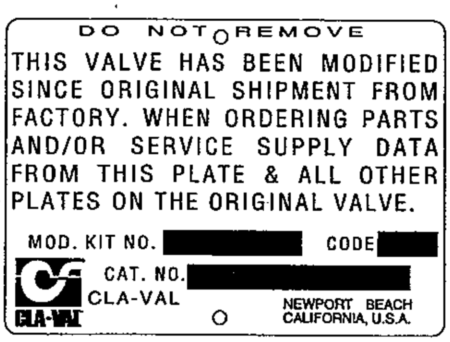
These two brass plates appear on 1" through 3" size screwed valves or 1" through 2" flanged valves . It is located on only one side of the valve body.



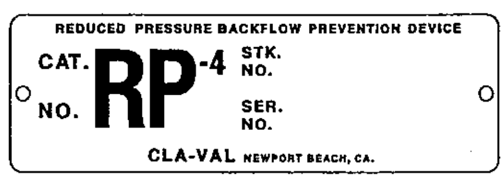
This tag is affixed to the cover of the pilot control valve. The adjustment range appears in the spring range section.



This brass plate is used to identify pilot control valves. The adjustment range is stamped into the plate.



This aluminum plate is included in pilot system modification kits and is to be wired to the new pilot control system after installation.



This brass plate is on our backflow prevention assemblies. It is located on the side of the number two check (2" through 10"). The serial number of the assembly is also stamped on the top of the inlet flange of the number one check.

HOW TO ORDER

There are many valves and controls manufactured by Cla-Val that are not listed due to the sheer volume. For information not listed, please contact your local Cla-Val office or our factory office located at:

P. O. Box 1325
Newport Beach, California 92659-0325
(949) 722-4800
FAX (949) 548-5441

SPECIFY WHEN ORDERING

- Model Number
- Globe or Angle Pattern
- Adjustment Range (As Applicable)
- Valve Size
- Screwed or Flanged
- Body and Trim Materials
- Optional Features
- Pressure Class

UNLESS OTHERWISE SPECIFIED

- Globe or angle pattern are the same price
- Ductile iron body and bronze trim are standard
- X46 Flow Clean Strainer or X43 "Y" Strainer are included
- CK2 Isolation Valves are included in price on 4" and larger valve sizes (6" and larger on 600 Series)

LIMITED WARRANTY

Automatic valves and controls as manufactured by Cla-Val are warranted for three years from date of shipment against manufacturing defects in material and workmanship which develop in the service for which they are designed, provided the products are installed and used in accordance with all applicable instructions and limitations issued by Cla-Val.

We will repair or replace defective material, free of charge, which is returned to our factory, transportation charges prepaid, provided that, after inspection, the material is found to have been defective at time of shipment. This warranty is expressly conditioned on the purchaser's giving Cla-Val immediate written notice upon discovery of the defect.

Components used by Cla-Val but manufactured by others, are warranted only to the extent of that manufacturer's guarantee.

This warranty shall not apply if the product has been altered or repaired by others, and Cla-Val shall make no allowance or credit for such repairs or alterations unless authorized in writing by Cla-Val.

DISCLAIMER OF WARRANTIES AND LIMITATIONS OF LIABILITY

The foregoing warranty is exclusive and in lieu of all other warranties and representations, whether expressed, implied, oral or written, including but not limited to any implied warranties or merchantability or fitness for a particular purpose. All such other warranties and representations are hereby cancelled.

Cla-Val shall not be liable for any incidental or consequential loss, damage or expense arising directly or indirectly from the use of the product. Cla-Val shall not be liable for any damages or charges for labor or expense in making repairs or adjustments to the product. Cla-Val shall not be liable for any damages or charges sustained in the adaptation or use of its engineering data and services. No representative of Cla-Val may change any of the foregoing or assume any additional liability or responsibility in connection with the product. The liability of Cla-Val is limited to material replacements F.O.B. Newport Beach, California.

TERMS OF SALE

ACCEPTANCE OF ORDERS

All orders are subject to acceptance by our main office at Newport Beach, California.

CREDIT TERMS

Credit terms are net thirty (30) days from date of invoice.

PURCHASE ORDER FORMS

Orders submitted on customer's own purchase order forms will be accepted only with the express understanding that no statements, clauses, or conditions contained in said order form will be binding on the Seller if they in any way modify the Seller's own terms and conditions of sales.

PRODUCT CHANGES

The right is reserved to make changes in pattern, design or materials when deemed necessary, without prior notice.

PRICES

All prices are F.O.B. Newport Beach, California unless expressly stated otherwise on our acknowledgement of the order. Prices are subject to change without notice. The prices at which any order is accepted are subject to adjustment to the Seller's price in effect at the time of shipment. Prices do not include sales, excise, municipal, state or any other Government taxes. Minimum order charge $75.00.

RESPONSIBILITY

We will not be responsible for delays resulting from strikes, accidents, negligence of carriers, or other causes beyond our control. Also, we will not be liable for any unauthorized product alterations or charges accruing there from.

RISK

All goods are shipped at the risk of the purchaser after they have been delivered by us to the carrier. Claims for error, shortages, etc., must be made upon receipt of goods.

EXPORT SHIPMENTS

Export shipments are subject to an additional charge for export packing.

RETURNED GOODS

1. Customers must obtain written approval from Cla-Val prior to returning any material.
2. Cla-Val reserves the right to refuse the return of any products.
3. Products more than six (6) months old cannot be returned for credit.
4. Specially produced, non-standard models cannot be returned for credit.
5. Rubber goods such as diaphragms, discs, o-rings, etc., cannot be returned for credit, unless as part of an unopened vacuum sealed repair kit which is less than six months old.
6. Goods authorized for return are subject to a 35% ($75 minimum) restocking charge and a service charge for inspection, reconditioning, replacement of rubber parts, retesting, repainting and repackaging as required.
7. Authorized returned goods must be packaged and shipped prepaid to Cla-Val, 1701 Placentia Avenue, Costa Mesa, California 92627.

CLA-VAL®

CLA-VAL
PO Box 1325 Newport Beach CA 92659-0325
Phone: 949-722-4800 • Fax: 949-548-5441

CLA-VAL CANADA, LTD.
4687 Christie Drive
Beamsville, Ontario
Canada L0R 1B4
Phone: 905-563-4963
Fax: 905-563-4040

CLA-VAL SA
Chemin des Mesanges 1
CH-1032 Romanel/
Lausanne, Switzerland
Phone: 41-21-643-15-55
Fax: 41-21-643-15-50
www.cla-val.com

E-Product I.D. (R-11/01)

Represented By:

CLA-VAL

— MODEL — **REPAIR KITS**

Complete Replacement Diaphragm Assemblies for 100-01 and 100-20 Hytrol Main Valves
For: Hytrol Main Valves with Ductile Iron, Bronze Trim Materials—**125/150 Pressure Class Only.**
FACTORY ASSEMBLED
Includes: Stem, Disc Guide, Disc, Disc Retainer, Spacer Washers, Diaphragm, Diaphragm Washer and Stem Nut.

Valve Size		Diaphragm Assembly Stock Number 100-01	100-20	Valve Size	Diaphragm Assembly Stock Number 100-01	100-20
3/8"	(Also 81-01)	49097K	N/A	6"	40456G	33273E
1/2" - 3/4"	(Also 81-01)	C2518D	N/A	8"	45276D	40456G
1"		C2520K	N/A	10"	81752J	45276D
1 1/4"-1 1/2"		C2522 F	N/A	12"	85533J	81752J
2"		C2524B	N/A	14"	89067D	N/A
2 1/2"		C2523D	N/A	16"	89068B	85533J
3"		C2525J	C2524B	20"	N/A	89068B
4"		33273E	C2525J	24"	N/A	89068B

Repair Kits for 100-01/100-20 Hytrol Valves
For: Hytrol Main Valves—**125/150 Pressure Class Only.**
Supplied Shrink Wrapped (4" and smaller) or Bagged (6" and larger)
Includes: Diaphragm, Disc (or Disc Assembly) and spare Spacer Washers.

Buna-N® Standard Material				Viton (For KB Valves)			
Valve Size		Repair Kit Stock Number 100-01	100-20	Valve Size		Repair Kit Stock Number 100-01	100-20
3/8"	(Also 81-01)	9169801K	N/A	3/8"	(Also 81-01)	9169806J	N/A
1/2" - 3/4"	(Also 81-01)	9169802H	N/A	1/2" - 3/4"	(Also 81-01)	9169807G	N/A
1"		9169803F	N/A	1"		9169808E	N/A
1 1/4" - 1 1/2"		9169804D	N/A	1 1/4" - 1 1/2"		9169809C	N/A
2"		9169805A	N/A	2"		9169810A	N/A
2 1/2"		9169811J	N/A	2 1/2"		9169817F	N/A
3"		9169812G	9169805A	3"		9169818D	9169810A
4"		9169813E	9169812G	4"		9169819B	9169818D
6"		9169815K	9169813E	6"		9169820K	9169819B
8"		9817901D	9169815K	8"		N/A	9169820K
10"		9817902B	9817901D				
12"		9817903K	9817902B				
14"		9817904H	N/A				
16"		9817905E	9817903K				
20"		N/A	9817905E				
24"		N/A	9817905E				

When ordering, please give complete nameplate data of the valve and/or control being repaired.
MINIMUM ORDER CHARGE APPLIES.

Repair Kits for 100-02/100-21 Powertrol and 100-03/100-22 Powercheck Main Valves
For: Powertrol and Powercheck Main Valves—**125/150 Pressure Class Only**
Supplied Shrink Wrapped (4" and Smaller) or Bagged (6" and larger)
Includes: Diaphragm, Disc (or Disc Assembly) and spare Spacer Washers.

Valve Size	Kit Stock Number 100-02	Valve Size	Kit Stock Number 100-02 &100-03	Kit Stock Number 100-21 &100-22
3/8"	9169901H	2 1/2"	9169910J	N/A
1/2" - 3/4"	9169902F	3"	9169911G	9169905J
1"	9169903D	4"	9169912E	9169911G
1 1/4" & 1 1/2"	9169904B	6"	9169913C	9169912E
2"	9169905J	8"	99116G	9169913C
		10"	N/A	99116G

Larger Sizes: Consult Factory.

Repair Kits for 100-04/100-23 Hy-Check Main Valves
For: Hy-Check Main Valves—**125/150 Pressure Class Only**
Supplied Shrink Wrapped (4" and Smaller) or Bagged (6" and larger)
Includes: Diaphragm, Disc and O-Rings and full set of spare Spacer Washers.

Valve Size	Kit Stock Number 100-04	Kit Stock Number 100-23	Valve Size	Kit Stock Number 100-04	Kit Stock Number 100-23
4"	20210901B	N/A	12"	20210905H	20210904J
6"	20210902A	20210901B	14"	20210906G	N/A
8"	20210903K	20210902A	16"	20210907F	20210905H
10"	20210904J	20210903K	20", 24"	N/A	20210907F

Larger Sizes: Consult Factory.

Repair Kits for Pilot Control Valves
Supplied Shrink Wrapped Includes: Diaphragm, Disc (or Disc Assembly), O-Rings, Gaskets or spare Screws as appropriate.

BUNA-N® (Standard Material)				VITON (For KB Controls)	
Pilot Control	Kit Stock Number	Pilot Control	Kit Stock Number	Pilot Control	Kit Stock Number
CDB	9170006C	CFM-7 & 7-A	1263901K	CDB-KB	9170012A
CDB-7	9170017K	CRA (w/bucking spring)	9170001D	CRA-KB	9170018H
CDH-2	18225D	CRD (w/bucking spring)	9170002B	CRD-KB (w/bucking spring)	9170008J
CDHS-2	44607A	CRD (no bucking spring)	9170003K	CRL-KB	9170013J
CDHS-2B	9170004H	CRD-22	98923G	CDHS-2BKB	9170010E
CDHS-2F	9170005E	CRL (55F, 55L)	9170007A	CDHS-2FKB	9170011C
CDHS-3C-A2	24657K	CRL-4A	43413E	CDHS-18KB (no bucking spring)	9170009G
CDHS-8A	2666901A	CRL-5 (55B)	65755B	102C-KB	1726202D
CDHS-18	9170003K	CRL-5A (55G)	20666E	**Buna-N®**	
CDS-4	9170014G	CV	9170019F		
CDS-5	14200A	X105L (O-ring)	00951E	CRD DISC RET. (SOLID)	C5256H
CDS-6	20119301A	102B-1	1502201F	CRD DISC RET. (SPRING)	C5255K
CFM-2, CFM-9, CFCM-M1	12223E	102C-2 & -3	1726201F		

Repair Assemblies (In Standard Materials Only)

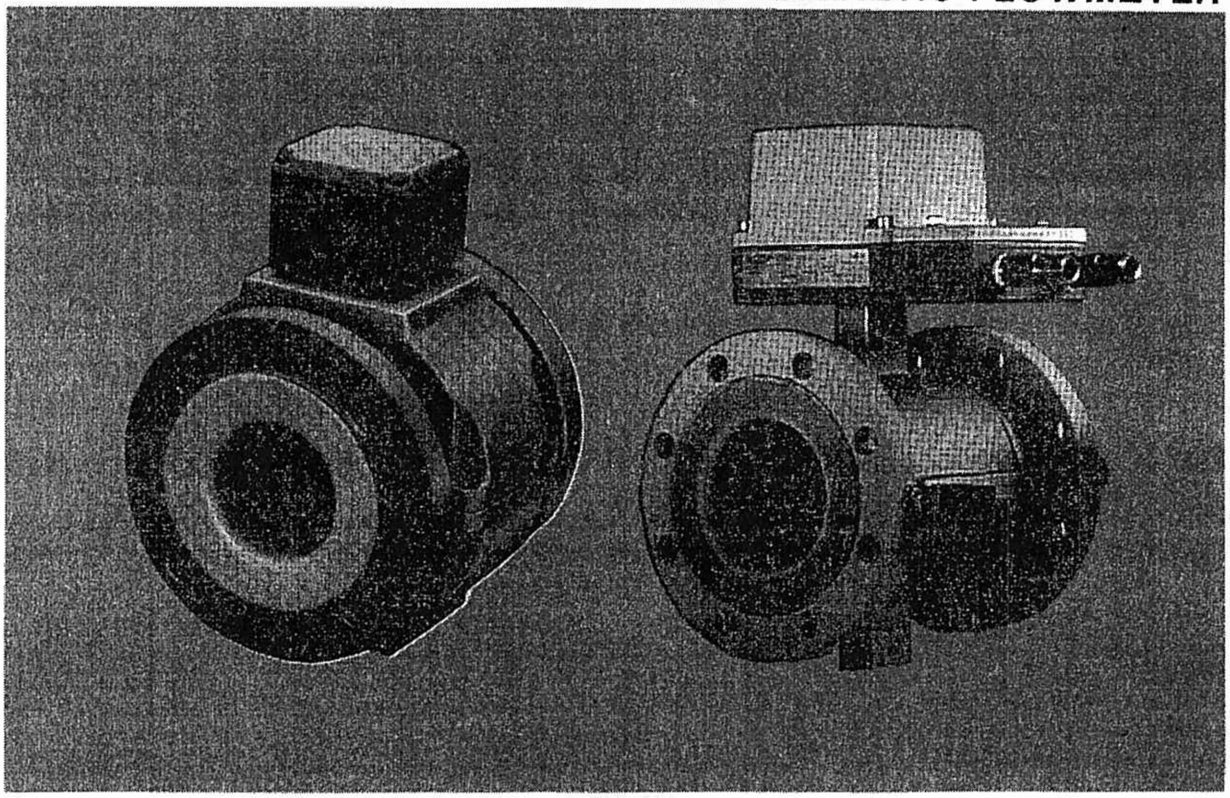
Control	Description	Stock Number
CF1-C1	Pilot Assembly Only	89541H
CF1-Cl	Complete Float Control less Ball & Rod	89016A
CFC2-C1	Disc, Distributor & Seals	2674701E
CSM 11-A2-2	Mechanical Parts Assy.	97544B
CSM 11-A2-2	Pilot Assembly Only	18053K
33A 1"	Complete Internal Assembly & Seal	2036030B
33A 2"	Complete Internal Assembly & Seal	2040830J

When ordering, please give complete nameplate data of the valve and/or control being repaired. MINIMUM ORDER CHARGE APPLIES

INSTRUCTION BULLETIN

MAGNETIC FLOWMETERS
10DX3111A & 10DX3111/3311G
Sizes 6 through 12 Inches

COPA-XM™ and MAG-X®
SERIES 3000 MAGNETIC FLOWMETER



PN24787A

ABB Instrumentation

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COPA-XM™
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WARNING notices as used in this manual apply to hazards or unsafe practices which could result in personal injury or death.

CAUTION notices apply to hazards or unsafe practices which could result in property damage.

NOTES highlight procedures and contain information which assist the operator in understanding the information contained in this manual.

WARNING

POSSIBLE PROCESS UPSETS
Maintenance must be performed only by qualified personnel and only after securing equipment controlled by this product. Adjusting or removing this product while it is in the system may upset the process being controlled. Some process upsets may cause injury or damage.

Table of Contents

Figure List

Table List

GÉNÉRAUX AVERTISSEMENTS

PROBLÈMES POTENTIELS. La maintenance doit être réalisée par du personnel qualifié et seulement après avoir sécurisé les équipements contrôlés par ce produit. L'ajustement ou le démontage de ce produit lorsqu'il est lié au système peut entraîner des dysfonctionnements dans le procédé qu'il contrôle. Ces dysfonctionnements peuvent entraîner des blessures ou des dommages.

RETOUR D'ÉQUIPEMENT. Tout débitmètre et(ou) convertisseur retourné à Fischer & Porter pour réparation doit être exempt de toute trace de produit dangereux (acide, base, solvant, ...). Un certificat de sécurité matériel doit être joint pour tous les liquides utilisés dans le procédé. Contacter Fischer & Porter pour autorisation avant renvoi du matériel.

MANUEL DE MISE EN ROUTE. Ne pas installer, maintenir ou utiliser cet équipement sans avoir lu, compris et suivi les instructions et manuels de Fischer & Porter, dans le cas contraire il y a risque d'entraîner blessures ou dommages.

RISQUE DE CHOC ÉLECTRIQUE
Les équipements alimentés en courant alternatif constituent un risque de choc électrique potentiel pour l'utilisateur. Assurez-vous que les câbles d'alimentation amont sont déconnectés avant de procéder à des branchements, des essais ou tests.

SPÉCIFIQUES AVERTISSEMENTS

Les équipements alimentés en courant alternatif constituent un risque de choc électrique potentiel pour l'utilisateur. Assurez-vous que les câbles d'alimentation amont sont déconnectés avant de procéder à des branchements, des essais ou tests. (pg. 2-16)

Tout débitmètre et(ou) convertisseur retourné à Fischer & Porter pour réparation doit être exempt de toute trace de produit dangereux (acide, base, solvant, ...). Un certificat de sécurité matériel doit être joint pour tous les liquides utilisés dans le procédé. Contacter Fischer & Porter pour autorisation avant renvoi du matériel. (pg. 5-1)

Les équipements alimentés en courant alternatif constituent un risque de choc électrique potentiel. La maintenance sur des équipements électromagnétiques ou des convertisseurs doit être effectuée par des techniciens qualifiés. (pg. 5-2)

RISQUE DE CHOC ÉLECTRIQUE
Les équipements alimentés en courant alternatif constituent un risque de choc électrique potentiel. Assurez-vous que la puissance est déconnectée avant de procéder aux mesures de résistance suivantes. (pg 5-3)

SPÉCIFIQUES ATTENTIONS

Ne pas utiliser un ohmmètre à courant continu pour cette mesure car les effets de polarisation conduiront à des mesures erronées. (pg. 4-3)

1.0 INTRODUCTION

1.1 General

1.1.1 Description

The Fischer & Porter Series 3000 Magnetic Flowmeter is a compact, volumetric, liquid flow rate detector that uses as the process transducing method the characteristic of a conductive liquid to generate an induced voltage when flowing through a magnetic field. The amplitude of the voltage produced is directly proportional to the flow rate of the metered liquid.

Being a completely obstructionless metering instrument, the Fischer & Porter Series 3000 Magnetic Flowmeter can be used to meter liquids without regard to heterogeneous consistency and will resist plugging or fouling as much as the pipeline it is mounted in. An inherent advantage of obstructionless construction is that pressure losses are reduced to levels occurring in equivalent lengths of equal diameter pipeline. This reduces or conserves pressure source requirements in new or existing hydraulic lines as compared to other metering methods. The compact size of the meter results in a light-weight unit which requires no additional support other than that used normally on pipe runs. Short laying lengths minimize the need for altering existing pipe runs to accommodate metering. A basic construction of corrosive resistant wetted parts and a variety of meter lining materials permit metering of most corrosive and reactant liquids.

Factors such as liquid viscosity and density require no compensation and have no effect on the measurement accuracy of the Magnetic Flowmeter. Metering limitations are confined to a minimum threshold of electrical conductivity inherent to the liquid being metered. The degree of liquid conductivity has no effect upon metering accuracy as long as it is greater than this minimum level. Liquid temperature is limited only to the extent that it may affect liquid conductivity and, like liquid pressure, to the extent that it can not exceed the meter material specification limits.

The associated electronics package is called the Signal Converter and may be either integrally or remotely mounted. Either an analog or a microprocessor signal converter may be used with the Series 3000 Magnetic Flowmeter. The Flowmeter without the electronics package is used with a remote mounted Signal Converter. A remotely mounted Signal Converter is recommended for any or all of the following conditions:

- if the summation of ambient and process temperature is greater than 262° F (110° C) for COPA-XM™, the Signal Converter must be remotely mounted.
- vibrations above the specification given in Section 1.3

The Signal Converter also contains a magnet driver unit that is used to power the meter's magnet coils. The steady bipolar state magnetic field principle, referred to as the MAG-X® design concept, provides optimum zero point stability at an optimized drive frequency.

For information concerning the Signal Converter, refer to the Signal Converter Instruction Bulletin.

1.1.2 Construction

The Fischer & Porter Series 3000 Magnetic Flowmeter consists of a flanged, stainless steel pipe spool which serves as a meter body. A pair of flat magnet coils fit on opposite sides of the meter housing inner surface. Permeable iron straps and pole pieces focus the magnetic field generated by the coils and provide a flux return path.

1.2.1 Model 10DX3111A

10D X 3 1 1 1 A _ _ _ _ _ _ _ _ _ _ _ _ _ 2 _

Field	Selection	Code
Engineering Reference	Obstructionless Magnetic Flowmeter	10D
Excitation		X
Primary Series 3000		3
Converter Type	Remote	1
Electrode Design	Conductive	1
Connection Type	Welded Flange	1
Design Level		A
Meter Lay Length	Standard 3000 Series (see Engineering)	A
	Short Form (WMAG)	D
	Replacement for 10D1419 & 10D1465	E
	Replacement for 10D1435	F
	Other	Z
Liner Material	Hard Rubber	A
	Polyurethane	D
	PTFE TEFLON	E
	Neoprene	L
	TEFZEL	N
Size	Inches (mm)	
	6 (150)	17
	8 (200)	18
	10 (250)	19
	12 (300)	20
Flange Standard Pressure Rating	DIN PN 10	C
	DIN PN 16	D
	DIN PN 25	E
	DIN PN 40	F
	ANSI Class 150	P
	ANSI Class 300	Q
Flange Material	Carbon Steel	1
	304 Stn. Steel	2
Protector Plate (TEFLON Liner only)	None Required	A
	316 Stn. Steel	B
	HASTELLOY C	E

1.1.3 10DX3111/3311G EEPROM Data

For 10DX3111/3311G Primaries, the calibration data of the Primary is electronically stored in an EEPROM located in the associated M2 Converter. This EEPROM is specific to an individual Primary and must be installed in conjunction with the Converter for proper operation. 10DX3111G Primaries and associated remote M2 Converters are available either as calibrated systems or individually as spare parts.

When the 10DX3111G Primary is calibrated as a system, the EEPROM is already installed in the remote Converter and the Converter only needs to have power applied to begin operating.

If a 10DX3111G Primary is supplied as a spare part, all calibration information about that Primary is stored in the EEPROM supplied with the Primary. The **new** EEPROM is stored in the terminal compartment of the Primary and must be used to replace the **old** EEPROM in the M2 Converter. For detailed information on replacing and installing the EEPROM, refer to Section 7.3.1 in the M2 Converter Instruction Bulletin.

Replacement integrally-mounted Converters (10DX3311G) already have the EEPROM installed at the factory and require no action on the customer's part.

1.2 Model Number Breakdown

Refer to the Fischer & Porter data sheet or data tag on the equipment for the model number of the instrument furnished. The details of a specific number are referenced on the following pages.

1.2.1 Model 10DX3111A (continued)

10D X 3 1 1 1 A _ _ _ _ _ _ _ _ _ _ _ _ 2 _

Electrode Type	
Flush	2
Bullet Nose	3
Flush (Slurry Service)	7

Electrode Material	
316 Stn. Steel	B
HASTELLOY® B	C
HASTELLOY® C	D
Titanium	E
Tantalum	F
Platinum / Iridium	H
Zirconium	L

Certification	
General Purpose	A
FM Approved-Nonincendive for CL I, Div 2, Gp A,B,C & D; Electrodes Intrinsically Safe for CL I, Div 1, Gp A,B,C & D; Outdoor Hazardous Locations, NEMA 4X. Dust-Ignitionproof CL II, Div 1, Gp E,F & G. Suitable for CL III, Div 1.	K
FM Approval pending - Explosionproof for CL I, Div 1, GP A,B,C & D; Dust-Ignitionproof CL II, Div 1, GP E,F & G; Suitable for CL III, Div 1. Electrodes Intrinsically Safe for CL I, Div 1, GP A, B, C & D - Outdoor Hazardous Location, NEMA 4X.	L

Enclosure Classification	
IEC 529 IP 65, NEMA 4X	1
Accidental Submergence, IEC 529 IP 67, NEMA 4X, 33ft H_2O/48h (10m H_20/48h)	2
Continuous Submergence, IEC 529 IP 68, NEMA 4X, 33ft H_2O (10m H_20)	5

Liquid Temperature Range	
Teflon, Rotomolded Tefzel, < 266° F (130° C)	1
Teflon, Extended Temperature, < 356° F (180° C)	2
Hard Rubber / Soft Rubber, < 176° F (80° C)	3
Neoprene / Polyurethane < 190° F (88° C)	4

Line Excitation Frequency	
50 Hz / 6-1/4 Hz	1
50 Hz / 12-1/2 Hz	2
60 Hz / 7-1/2 Hz	3
60 Hz / 15 Hz	4

Customer Information Language	
English	2

Converter Type	
50XM1000	1
none	X

1.2.2 Model 10DX3111G

10DX3111 G _ _ _ _ _ _ _ _ _ _ _

Option	Code
Engineering Reference	
Design Level	G
Meter Lay Length	
Short Form (WMAG)	D
Replacement for 10D1419 & 1465	E
Replacement for 10D1435	F
Other (Refer to Engineering	Z
Liner Material	
Hard Rubber	A
Polyurethane	D
PTFE Teflon	E
Neoprene	L
Rotomolded Tefzel	N
Size - Inches (mm)	
6 (150)	17
8 (200)	18
10 (250)	19
12 (300)	20
Flange Standard / Pressure Rating	
DIN PN10	C
DIN PN16	D
DIN PN25	E
DIN PN40	F
ANSI Class 150	P
ANSI Class 300	Q
Flange Material	
Carbon Steel	1
304 Stainless Steel	2
Protector Plates	
None Required	A
316 SS	B
Hastelloy-C	E
Electrode Type	
Flush	2
Bullet Nose	3
Flush (Slurry service)	7
Electrode Material	
316 SS	B
Hastelloy-B	C
Hastelloy-C	D
Titanium	E
Tantalum	F
Platinum/Iridium	H
Zirconium	L

1.2.2 Model 10DX3111G (continued)

10DX3111 G _ _ _ _ _ _ _ _

Certification	
Standard (None)	A
FM Approved - Nonincendive for CL I, Div 2, Gp A, B, C & D; Electrodes Intrinsically Safe for CL I, Div 1, Gp A, B, C & D; Outdoor Hazardous Locations , NEMA 4X. Dust-Ignition-Proof CL II, Div 1, Gp E, F & G; Suitable for CL III, Div 1.	K
FM Approved - Explosionproof for CL I, Div 1, Gp B, C & D; Dust-Ignition-Proof CL II, Div 1. Gp E, F & G; suitable for CL III, Div 1; Electrodes Intrinsically Safe for CL I, Div 1, Gp A, B, C & D - Outdoor Hazardous Location, NEMA 4X.	L
Enclosure Classification	
General Purpose: IEC 529, IP65, NEMA 4X	1
Accidental Submergence: IEC 529, IP67, NEMA 4X. 33 ft H_2O/48 hr (10 m H_2O/48 hr)	2
Accidental Submergence: IEC 529, IP67, NEMA 4X. 33 ft H_2O/48 hr (10 m H_2O/48 hr). Tropical High-Moisture Protection, Signal cable permanently installed.	4
Continuous Submergence: IEC 529, IP68, NEMA 4X. 33 ft H_2O/48 hr (10 m H_2O/48 hr). Continuous Duty. Signal cable permanently installed.	5
Accidental Submergence: IEC 529, IP67, NEMA 4X. 33 ft H_2O/48 hr (10 m H_2O/48 hr). Tropical-Improved Moisture Protection, Signal cable permanently installed.	9
Fluid Temperature Range	
Teflon, Rotomolded Tefzel, < 266°F (130°C)	1
Teflon extended temperature, < 356°F (180°C)	2
Hard Rubber/ Soft Rubber, < 176°F (80°C)	3
Neoprene/Polyurethane, < 190°F (88°C)	4
Line/Excitation Frequency	
50 Hz / 6 1/4 Hz	1
50 Hz / 12 1/2 Hz	2
60 Hz / 7 1/2 Hz	3
60 Hz / 15 Hz	4
Customer Information Language	
English w/ riveted SS tag	2
English w/ self-adhesive tag	8
Converter Type	
M2	1
None	X

1.2.3 Model 10DX3311G

10DX3311 G _ _ _ _ _ _ _ _ _ 1 _ X _ A _ _

Option	Code
Engineering Reference	
Design Level	G
Meter Lay Length	D
Short Form (WMAG)	E
Replacement for 10D1419 & 1465	F
Replacement for 10D1435	Z
Other (Refer to Engineering	
Liner Material	
Hard Rubber	A
Polyurethane	D
PTFE Teflon	E
Neoprene	L
Rotomolded Tefzel	N
Size - Inches (mm)	
6 (150)	17
8 (200)	18
10 (250)	19
12 (300)	20
Flange Standard / Pressure Rating	
DIN PN10	C
DIN PN16	D
DIN PN25	E
DIN PN40	F
ANSI Class 150	P
ANSI Class 300	Q
Flange Material	
Carbon Steel	1
304 Stainless Steel	2
Protector Plates	
None Required	A
316 SS	B
Hastelloy-C	E
Electrode Type	
Flush	2
Bullet Nose	3
Flush (Slurry service)	7
Electrode Material	
316 SS	B
Hastelloy-B	C
Hastelloy-C	D
Titanium	E
Tantalum	F
Platinum/Iridium	H
Zirconium	L

1.2.3 Model 10DX3311G (continued)

10DX3311 G _ _ _ _ _ _ _ _ _ _ 1 _ _ X _ A _ _ _

Certification	
Standard (None)	A
FM Approved - Nonincendive for CL I, Div 2, Gp A, B, C & D; Electrodes Intrinsically Safe for CL I, Div 1, Gp A, B, C & D; Outdoor Hazardous Locations , NEMA 4X. Dust-Ignition-Proof CL II, Div 1, Gp E, F & G; Suitable for CL III, Div 1; Accidental Submergence, 33 ft H_2O/48 hr (10 m H_2O/48 hr)	K
Enclosure Classification	
General Purpose: IEC 529, IP65, NEMA 4X	1
Accidental Submergence: IEC 529, IP67, NEMA 4X. 33 ft H_2O/48 hr (10 m H_2O/48 hr)	2
Accidental Submergence: IEC 529, IP67, NEMA 4X. 33 ft H_2O/48 hr (10 m H_2O/48 hr). Tropical High-Moisture Protection.	4
Fluid Temperature Range	
Standard	1
Excitation Frequency	
6 1/4 Hz (50 Hz line)	1
12 1/2 Hz (50 Hz line)	2
7 1/2 Hz (60 Hz line)	3
15 Hz (60 Hz line)	4
12 1/2 Hz (DC power in vicinity of 50 Hz line)	6
15 Hz (DC power in vicinity of 60 Hz line)	8
Other Frequency (not currently available)	9
Customer Information Language	
English w/ riveted SS tag	2
English w/ self-adhesive tag	8
Software Level	
Generation	X
Pulse Output / Data Link	
None / None	0
Active Scaled Pulse Fwd & Rev / None	1
None / RS485 Port	4
None / RS232 Port	5
None / Bailey FSK	9
Measuring Mode	
Continuous Flow Measurement	A

1.2.3 Model 10DX3311G (continued)

10DX3311 G _ _ _ _ _ _ _ _ _ _ 1 _ _ X _ A _ _ _ _

Option Terminals	
None	A
Alarm, Opto-coupled	D
External Zero Return	F
External Totalizer Reset	G
Forward Pulse Output, Opto-coupled (presently not available)	K

Accessories	
Without	A
Empty Pipe Detection (presently not available)	B
HART Protocol	C
Empty Pipe Detection & HART Protocol (presently not available)	D

Power Supply	
220/230/240 VAC, 50/60 Hz	A
110/115/120 VAC, 50/60 Hz	C
48 VAC, 50/60 Hz	E
24 VAC, 50/60 hZ	F
48 VDC	G
24 VDC	H

Converter	
Required	1
None (Primary only)	2

1.3 Specifications

Power Requirements	Refer to Section 1.2 Model Number Breakdown.
Power Consumption	Refer to Signal Converter Instruction Bulletin.
Flowmeter Characteristics	
Meter Size/Flow Capacity	Refer to Table 1-4.
Span	Factory set at specified range between extremes listed in Table 1-4; can be field adjusted.
Rangeability	100:1
Minimum Liquid Conductivity	5 μS/cm
System Accuracy	Refer to Signal Converter Instruction Bulletin.
Meter Capacity	Specified on Flowmeter data tag (equal to maximum flow capacity in engineering units). Refer to Table 1-4.
Environmental Limits	
Ambient Temperature	Models 10DX3111: -13° to 140° F (-25° to 60° C) Model 10DX3311: -13° to 122° F (-25° to 50° C)
Relative Humidity	10% to 90%

Process Limits

TABLE 1-1. MAXIMUM LIQUID TEMPERATURE

Liner Material	Temperature
TEFLON, Model 10DX3111	356° F [180° C]
TEFZEL, Model 10DX3111	300° F [149° C]
TEFLON / TEFZEL, Model 10DX3311	266° F [130° C]
Neoprene/Polyurethane	190° F [88° C]
Hard Rubber	175° F [80° C]

TABLE 1-2. PRESSURE RATING, MPa (psig)

Flange Class	Flange Material	Temperature				
		100° F [38° C]	175° F [80° C]	190° F [88° C]	266° F [130° C]	356° F [180° C]
ANSI 150	Carbon Steel	1.96 (285)	1.82 (265)	1.81 (262)	1.65 (240)	1.47 (213)
	304 sst	1.90 (275)	1.69 (245)	1.65 (239)	1.48 (215)	1.32 (191)
ANSI 300	Carbon Steel	5.10 (740)	4.76 (690)	4.70 (682)	4.56 (662)	4.44 (644)
	304 sst	4.96 (720)	4.34 (630)	4.22 (612)	3.82 (554)	3.42 (496)
DIN PN6	Carbon Steel	0.60 (87)	0.60 (87)	0.60 (87)	0.59 (86)	0.57 (82)
	304 sst	0.58 (84)	0.57 (82)	0.57 (82)	0.54 (79)	0.50 (73)
DIN PN10	Carbon Steel	1.00 (145)	1.00 (145)	1.00 (145)	1.00 (145)	1.00 (145)
	304 sst	0.97 (140)	0.94 (137)	0.94 (137)	0.92 (133)	0.88 (128)
DIN PN16	Carbon Steel	1.60 (232)	1.60 (232)	1.60 (232)	1.60 (232)	1.60 (232)
	304 sst	1.54 (224)	1.51 (219)	1.50 (218)	1.46 (212)	1.41 (205)
DIN PN25	Carbon Steel	2.50 (362)	2.50 (362)	2.50 (362)	2.50 (362)	2.50 (362)
	304 sst	2.43 (352)	2.28 (331)	2.25 (327)	2.10 (304)	1.93 (280)
DIN PN40	Carbon Steel	4.00 (580)	4.00 (580)	4.00 (580)	4.00 (580)	4.00 (580)
	304 sst	3.89 (564)	3.65 (530	3.62 (525)	3.36 (488)	3.10 (449)

TABLE 1-3. VACUUM LIMIT

Liner Material	Temperature			
	68° F [20° C]	212° F [100° C]	266° F [130° C]	356° F [180° C]
TEFLON	3.0 psia	5.8 psia	6.7 psia	8.7 psia
Neoprene Polyurethane Hard Rubber	Full Vacuum To 190° F [88° C]			
TEFZEL	Full Vacuum To 300° F [149° C]			

TABLE 1-4. METER CAPACITY VALUES

Meter Size		Meter Capacity*	Flow Ranges 0 to Value Tabulated			
			Minimum		Maximum	
inch	mm	gpm	gpm	L/min	gpm	L/min
6	150	2641.72	265.0	60.0	2641.0	600.0
8	200	4755.09	476.0	108.0	4755.0	1080.0
10	250	7925.16	793.0	180.0	7925.0	1800.0
12	300	10566.8	1056.0	240.0	10567.0	2400.0

* Each meter is calibrated to determine its flow capacity at a given velocity, which has been established by Fischer & Porter as 32.808 ft/s (10 m/s) for the Meter Capacity. The Meter Capacity expressed in gpm is recorded on the meter nameplate.

All series 3000 meters are calibrated at 32.808 ft/s (10 m/s). Note that the display on the Signal Converter supplied may read "Cal Factor" even when configured for 32.808 ft/s (10 m/s).

The Meter Capacity is the base upon which maximum and minimum limits for range settings and outputs are established.

Flow Velocity can be determined as follows:

Meter Capacity:

Flow Velocity (ft/s) = (Operating gpm x 32.808)/Meter Capacity

> NOTE
> The maximum meter flow range is a function of the Signal Converter used. The maximum flow range may exceed the meter capacity to allow for overrange.

Physical Characteristics

Outline Dimensions	See Figures 2-3 through 2-8.
Vibration Limits	10 to 150 Hz, 1.5g

Signal Cable for Remote Converter (supplied by Fischer & Porter, when applicable)

Standard Length	30 feet (9 m)
Optional Length	10DX3111A: up to 500 ft. 10DX3111G: up to 250 ft.

Materials of Construction

Meter Liner	see Section 1.2 Model Number Breakdown
Electrode Assembly	see Section 1.2 Model Number Breakdown
Meter Body	304 sst, epoxy finish
Flanges	carbon steel or 304 sst, as specified
Meter Housing	aluminum, epoxy finish
Electronics Housing	cast aluminum, epoxy finish, 316 sst attachment screws, gasketed covers

Primary Enclosure Ratings

Watertight Housing (standard)	NEMA 4X, IEC 529 IP65
Accidental Submergence	NEMA 4X, IEC 529 IP67, 33 feet H_2O/48 h (10 m H_2O/48 h)
Continuous Submergence	NEMA 4X, IEC 529 IP 68, 33ft H_2O (10m H_20)
Conduit Connections	Remote Converter - two 1/2 inch NPT internally threaded entrances

> NOTE
> Enclosures are suitable for indoor or outdoor installation.

Certifications	refer to Section 1.2, Model Number Breakdown

2.0 INSTALLATION

2.1 Inspection

All Fischer & Porter Series 3000 Magnetic Flowmeters are shipped in heavy duty containers which are specially designed to provide adequate protection during transit. Since the Magnetic Flowmeter will be operated in conjunction with an electronic Signal Converter, both instruments may be in the same shipping container. An itemized list of all items included in the shipment is attached to the shipping container. Refer to the Instruction Bulletin supplied with the associated Signal Converter for operation and maintenance procedures for the particular Converter.

If the specified Magnetic Flowmeter is supplied with a remote Signal Converter, thirty feet of interconnection cable(standard) and conduit or cable seals will be included in the shipment.

Inspect all items included in the shipment immediately for indications of damage which may have occurred during shipment. All damage claims should be reported to the shipping agent involved before attempting to install or operate this equipment. If the damage is such that faulty operation is likely to result, the damage should be brought to the attention of the Fischer & Porter Service Department.

2.2 Meter Handling

The liner of the flowmeter may be damaged if it comes in contact with a sharp object and must be protected at all times.

When a TEFLON lined meter is specified, two liner protector plates (one on each flange face) are factory installed (when specified at time of order). These plates serve to contain the flared ends of the liner, and to prevent damage to the liner during installation and handling. These protector plates are attached to the meter with flat head screws that securely hold the liner in place. If the pressure on the liner is relieved, the TEFLON will tend to curl away from the flange. These protector plates must remain in place when the meter is installed. Refer to Figure 2-1 for a view of these protector plates. Also, due to the susceptibility of the meter to moisture penetration behind the liner before installation in the pipeline, TEFLON-lined meters should not be stored outdoors in uncovered areas, in wet locations or subjected to cleaning operations with excessive liquids prior to being fully installed in the pipeline.

During shipment, the liner is protected by wood or composition protectors as shown in Figure 2-2 (standard); these are removed before the meter is installed. These protectors should be left in position while moving the meter to the installation site. In the case of wood protectors, make certain there are no wood chips between the liner and the meter flange face prior to installation.

To place the meter in the pipeline a sling and hoist may be necessary. Do not pass any rope or wire sling through the meter; the liner will be damaged if the meter is supported by the liner. Lift the meter as shown in Figure 2-2.

Table 2-1 lists the weights of the meters by size and flange classification. Weights shown are approximate and should be used only as a guide when installing the meter.

TABLE 2-1. METER WEIGHTS

Meter Size		ANSI Class 150		ANSI Class 300		DIN PN 10		DIN PN 16		DIN PN 25		DIN PN 40	
Inches	mm	lbs	kg	lbs	kg	lbs	kg	lbs	kg	lbs	kg	lbs	kg
6	150	105	47	140	64	105	47	105	47	140	64	140	64
8	200	155	70	210	95	155	70	155	70	210	95	210	95
10	250	220	100	295	134	220	100	220	100	295	134	295	134
12	300	275	125	365	166	275	125	275	125	365	166	365	166

If the continuous submergence option is chosen for Model 10DX3111, the meter weights shown above must be modified by adding the weights shown in the following table:

TABLE 2-2. CONTINUOUS SUBMERGENCE WEIGHT FACTORS

Meter Size		Add to Meter Weight from Table Above	
Inches	mm	lbs	kg
6	150	11.23	5.1
8	200	15.57	7.1
10	250	23.27	10.6
12	300	50.47	22.9

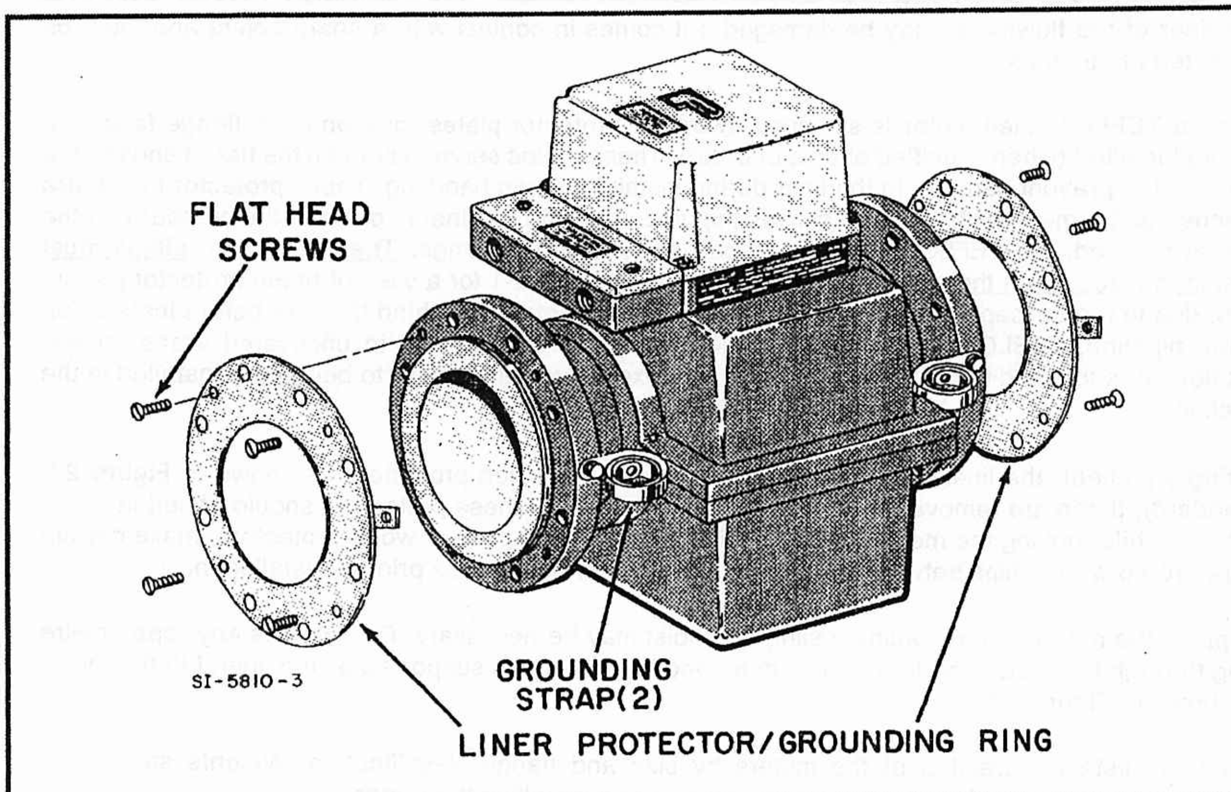
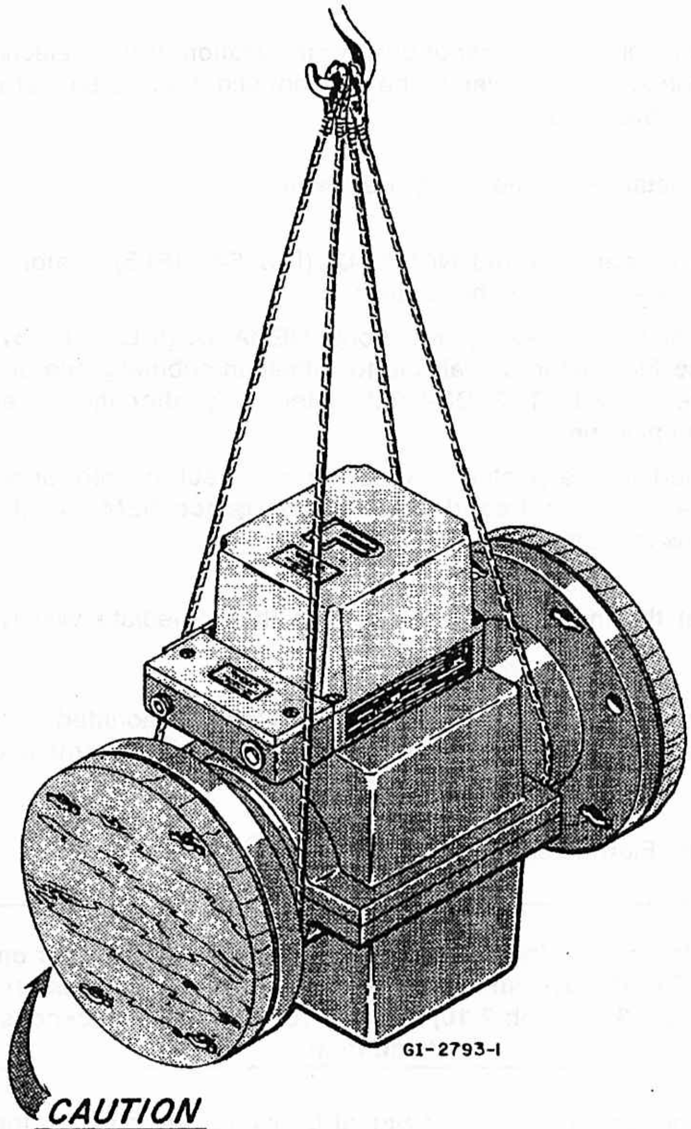


FIGURE 2-1. PROTECTOR PLATES FOR TEFLON LINERS



CAUTION

DO NOT PUT SLING THRU METER LINER.

DO NOT REMOVE METAL LINER PROTECTOR AT ANYTIME.

REMOVE WOOD SHIPPING PROTECTOR (SHOWN) AT THE TIME OF ACTUAL INSTALLATION IN THE PIPELINE.

FIGURE 2-2. PROPER HOISTING METHOD

Note that the flowmeter shown in this illustration is not the meter described in this instruction bulletin.

2.3 Location

The Flowmeter is suitable for either indoor or outdoor installation. When selecting the location of the installation, consideration should be given to the ambient and process temperature limits, as stated in the Specifications Sub-Section 1.3.

Several variations of resistance to water-entry are available:

- The Standard meter is rated NEMA 4X (IEC 529 IP65), watertight, and will withstand periods of rain and hose down.
- If periodic flooding may occur, an optional NEMA 4X (IEC 529 IP67) **accidental submergence** Flowmeter is available to withstand submergence up to 48 hours. These ratings apply to TEFLON-lined meters only after the meter is properly installed in the pipeline.
- If periodic flooding is expected to keep the meter submerged for periods longer than 48 hours, an optional **continuous submergence** NEMA 4X (IEC 529 IP68) configuration is available.

It is recommended that the meter not be installed in the immediate vicinity of heavy induction equipment.

Access for wiring interconnections and servicing of the integrally mounted Signal Converter should be considered when installing the meter. A minimum of five inches of overhead clearance is required for cover removal.

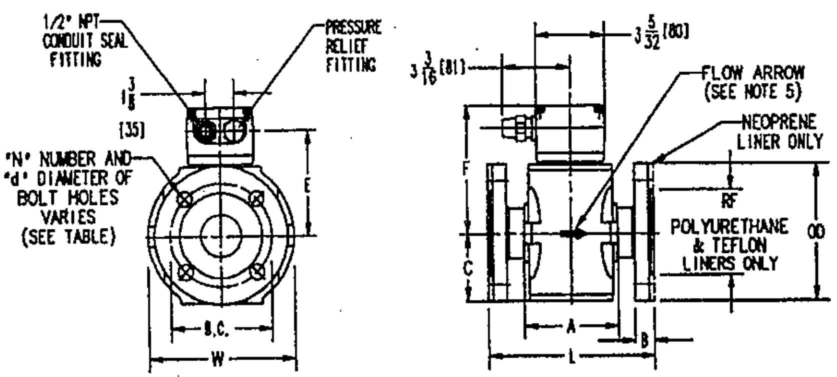
Outline dimensions of the Flowmeter are given in Figures 2-3 through 2-10.

NOTE
When using grounding rings and gaskets, add 1/8 inch per end (1/4 inch total) to the overall meter installation length (dimension "L" in Figures 2-3 through 2-10) to allow for the added thickness of these items.

Outline dimensions of the remotely mounted Signal Converter are given in the Instruction Bulletin supplied with the Signal Converter.

The installation site must be provided with a convenient source of power as specified for the Signal Converter. The power line should have a disconnect switch and a suitable fuse or circuit breaker as shown on the applicable interconnection diagram provided in the Instruction Bulletin supplied with the Signal Converter.

DIM	SIZE	1/2 (15)		1 (25)		1-1/2(40)		2 (50)		3 (80)		4 (100)		6 (150)		8 (200)		10 (250)		12(300)	
		OUTLINE DIMENSIONS inches (mm)																			
	ANSI FLG CL	150	300	150	300	150	300	150	300	150	300	150	300	150	300	150	300	150	300	150	300
	MODEL NO.																				
L	10D S/X 3111AD	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	9-7/8 (250)	11 (280)	11-13/16 (300)		13-25/32 (350)		17-23/32 (450)		19-11/16 (500)	
L	10D S/X 3111AE	14 (356)		14 (356)		16 (406)		16 (406)		12 (305)		12 (305)		17-23/32 (450)		19-11/16 (500)		21-21/32 (550)		24-13/32 (620)	
L	10D S/X 3111AF	NA		NA		NA		NA		NA		NA		NA		NA		NA		18 (457)	
	LINER																				
RF	NEOPRENE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RF	OTHERS	1-3/8 (35)		2 (51)		2-7/8 (73)		3-5/8 (92)		5 (127)		6-3/16 (157)		8-1/2 (216)		10-5/8 (270)		12-3/4 (324)		15 (381)	
B	POLY/NEOP	NA	NA	NA	NA	NA	NA	15/16 (24)	1-1/16 (27)	1-1/8 (29)	1-5/16 (33)	1-1/8 (29)	1-7/16 (36)	1-3/16 (30)	1-5/8 (41)	1-5/16 (33)	1-13/16 (46)	1-3/8 (35)	2-1/16 (52)	1-1/2 (38)	2-1/4 (57)
B	TEFLON	1/2 (13)	5/8 (16)	11/16 (17)	13/16 (21)	27/32 (21)	31/32 (25)	29/32 (23)	1-1/32 (26)	1-3/32 (27)	1-9/32 (32)	1-3/32 (27)	1-13/32 (35)	1-1/8 (29)	1-9/16 (40)	1-9/32 (33)	1-25/32 (45)	1-3/8 (35)	2-1/16 (52)	1-1/2 (38)	2-1/4 (57)
B	TEFZEL			5/8 (16)	3/4 (19)	3/4 (19)	7/8 (22)	27/32 (21)	31/32 (25)	1-1/16 (27)	1-1/4 (32)	1-1/16 (27)	1-3/8 (35)	1-1/8 (29)	1-9/16 (40)	1-1/4 (32)	1-3/4 (44)	1-5/16 (33)	2 (51)	1-25/64 (35)	2-9/64 (54)
d		5/8 (16)		5/8 (16)	3/4 (19)	5/8 (16)	7/8 (22)	3/4 (19)	3/4 (19)	3/4 (19)	7/8 (22)	3/4 (19)	7/8 (22)	7/8 (22)	7/8 (22)	7/8 (22)	1 (25)	1 (25)	1-1/8 (29)	1 (25)	1-1/8 (29)
N		4	4	4	4	4	4	4	8	4	8	8	8	8	12	8	12	12	16	12	16
BC		2-3/8 (60)	2-5/8 (67)	3-1/8 (79)	3-1/2 (89)	3-7/8 (98)	4-1/2 (114)	4-3/4 (121)	5 (127)	6 (152)	6-5/8 (168)	7-1/2 (191)	7-7/8 (200)	9-1/2 (241)	10-5/8 (270)	11-3/4 (298)	13 (330)	14-1/4 (362)	15-1/4 (387)	17 (432)	17-3/4 (451)
OD		3-1/2 (89)	3-3/4 (95)	4-1/4 (108)	4-7/8 (124)	5 (127)	6-1/8 (156)	6 (152)	6-1/2 (165)	7-1/2 (190)	8-1/4 (210)	9 (229)	10 (254)	11 (279)	12-1/2 (318)	13-1/2 (343)	15 (381)	16 (406)	17-1/2 (445)	19 (483)	20-1/2 (521)
A		4-13/16 (122)		4-13/16 (122)		4-13/16 (122)		4-13/32 (112)		4-13/32 (112)		5-1/8 (130)		6-11/16 (170)		7-11/16 (195)		9-27/32 (250)		9-27/32 (250)	
C		2-27/32 (73)		2-27/32 (73)		2-27/32 (73)		3-7/32 (82)		3-7/8 (98)		4-21/32 (118)		5-25/32 (147)		7-1/16 (179)		8-5/32 (207)		9-27/32 (250)	
E		4-17/32 (115)		4-17/32 (115)		4-17/32 (115)		4-7/8 (124)		5-1/2 (140)		6-9/32 (160)		7-1/2 (190)		8-3/4 (222)		9-27/32 (250)		12-9/16 (319)	
F		5-19/32 (142)		5-19/32 (142)		5-19/32 (142)		5-15/16 (150)		6-17/32 (166)		7-5/16 (186)		8-1/2 (216)		9-3/4 (248)		10-7/8 (276)		13-19/32 (345)	
W		6-17/32 (166)		6-17/32 (166)		6-17/32 (166)		7-3/32 (180)		7-7/8 (200)		9-7/16 (240)		12-3/16 (310)		14-3/8 (365)		16-25/32 (426)		20-5/64 (510)	



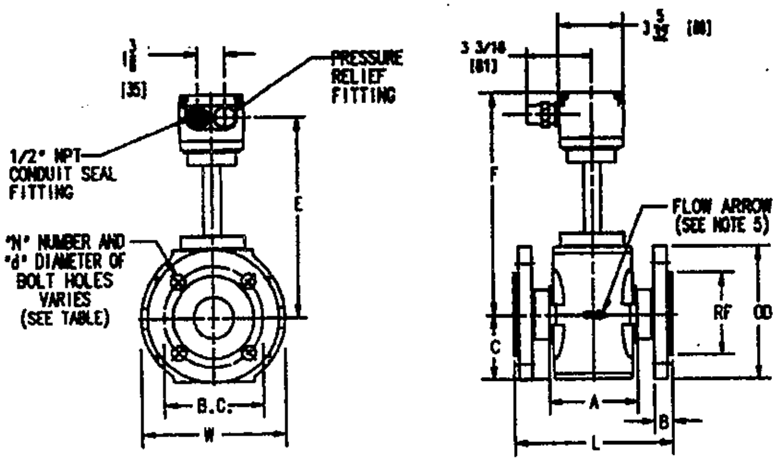
NOTES
1) ALL DIMENSIONS ARE IN INCHES, DIMENSIONS IN PARENTHESIS [ ] ARE IN MILLIMETERS (mm).
2) DIMENSIONS ARE GUARANTEED ONLY IF THIS PRINT IS CERTIFIED.
3) THIS DRAWING IS A THIRD ANGLE PROJECTION AS SHOWN.
4) FLANGE BOLT HOLES STRADDLE CENTERLINES
5) FLOW MUST BE IN SAME DIRECTION AS FLOW ARROW.
6) METER MUST BE COMPLETELY FILLED WITH LIQUID TO INSURE ACCURACY.
7) ALL DIMENSIONS SUBJECT TO MANUFACTURING TOLERANCES OF +/-1/8 [3].

FIG. 2-3. OUTLINE DIMENSIONS, REMOTE CONVERTER WITH ANSI FLANGES

(OD-10D-4123 R2)

DIM	SIZE	1/2 (15)		1 (25)		1-1/2 (40)		2 (50)		3 (80)		4 (100)		6 (150)		8 (200)		10 (250)		12 (300)	
	ANSI FLG CL	150	300	150	300	150	300	150	300	150	300	150	300	150	300	150	300	150	300	150	300
	MODEL NO.																				
L	100 S/X 3111AD	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	9-7/8 (250)	11 (280)	11-13/16 (300)		13-25/32 (350)		17-23/32 (450)		19-11/16 (500)	
L	100 S/X 3111AE	14 (356)		14 (356)		16 (406)		16 (406)		12 (305)		12 (305)		17-23/32 (450)		19-11/16 (500)		21-21/32 (550)		24-13/32 (620)	
L	100 S/X 3111AF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		18 (457)	
RF		1-3/8 (35)		2 (51)		2-7/8 (73)		3-5/8 (92)		5 (127)		6-3/16 (157)		8-1/2 (216)		10-5/8 (270)		12-3/4 (324)		15 (381)	
B		1/2 (13)	5/8 (16)	11/16 (17)	13/16 (21)	27/32 (21)	31/32 (25)	29/32 (23)	1-1/32 (26)	1-3/32 (27)	1-9/32 (32)	1-3/32 (27)	1-13/32 (35)	1-1/8 (29)	1-9/16 (40)	1-9/32 (33)	1-25/32 (45)	1-3/8 (35)	2-1/16 (52)	1-1/2 (38)	2-1/4 (57)
d		5/8 (16)		5/8 (16)	3/4 (19)	5/8 (16)	7/8 (22)	3/4 (19)	3/4 (19)	3/4 (19)	7/8 (22)	3/4 (19)	7/8 (22)	7/8 (22)	7/8 (22)	7/8 (22)	1 (25)	1 (25)	1-1/8 (28)	1 (25)	1-1/8 (29)
N		4	4	4	4	4	4	4	8	4	8	8	8	8	12	8	12	12	16	12	16
BC		2-3/8 (60)	2-5/8 (67)	3-1/8 (79)	3-1/2 (89)	3-7/8 (98)	4-1/2 (114)	4-3/4 (121)	5 (127)	6 (152)	6-5/8 (168)	7-1/2 (191)	7-7/8 (200)	9-1/2 (241)	10-5/8 (270)	11-3/4 (298)	13 (330)	14-1/4 (362)	15-1/4 (387)	17 (432)	17-3/4 (451)
OD		3-1/2 (89)	3-3/4 (95)	4-1/4 (108)	4-7/8 (124)	5 (127)	6-1/8 (156)	6 (152)	6-1/2 (165)	7-1/2 (190)	8-1/4 (210)	9 (229)	10 (254)	11 (279)	12-1/2 (318)	13-1/2 (343)	15 (381)	16 (406)	17-1/2 (445)	19 (483)	20-1/2 (521)
A		4-13/16 (122)		4-13/16 (122)		4-13/16 (122)		4-13/32 (112)		4-13/32 (112)		5-1/8 (130)		6-11/16 (170)		7-11/16 (195)		9-27/32 (250)		9-27/32 (250)	
C		2-27/32 (73)		2-27/32 (73)		2-27/32 (73)		3-7/32 (82)		3-7/8 (98)		4-21/32 (118)		5-25/32 (147)		7-1/16 (179)		8-5/32 (207)		9-27/32 (250)	
E		9-9/32 (236)		9-9/32 (236)		9-9/32 (236)		9-5/8 (245)		10-1/4 (260)		11-1/32 (280)		12-1/4 (311)		13-1/2 (343)		14-19/32 (371)		16-9/32 (421)	
F		10-11/32 (263)		10-11/32 (263)		10-11/32 (263)		10-11/16 (271)		11-5/16 (287)		12-3/32 (307)		13-5/16 (338)		14-9/16 (370)		15-21/32 (398)		17-5/16 (440)	
W		6-17/32 (166)		6-17/32 (166)		6-17/32 (166)		7-3/32 (180)		7-7/8 (200)		9-7/16 (240)		12-3/16 (310)		14-3/8 (365)		16-25/32 (426)		20-5/64 (510)	

OUTLINE DIMENSIONS inches (mm)



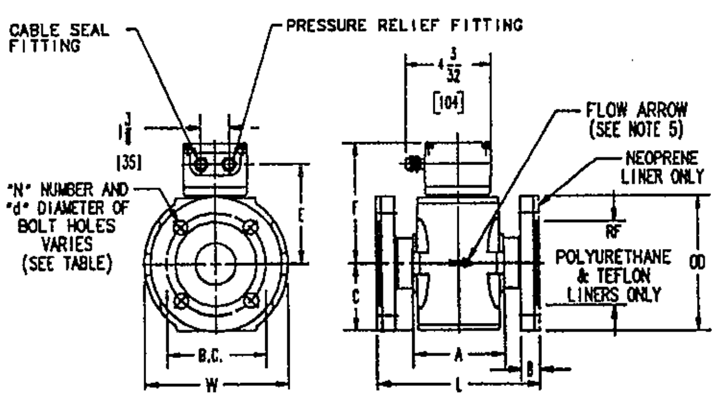
NOTES
1) ALL DIMENSIONS ARE IN INCHES. DIMENSIONS IN PARENTHESIS [ ] ARE IN MILLIMETERS [mm].
2) DIMENSIONS ARE GUARANTEED ONLY IF THIS PRINT IS CERTIFIED.
3) THIS DRAWING IS A THIRD ANGLE PROJECTION AS SHOWN.
4) FLANGE BOLT HOLES STRADDLE CENTERLINES
5) FLOW MUST BE IN SAME DIRECTION AS FLOW ARROW.
6) METER MUST BE COMPLETELY FILLED WITH LIQUID TO INSURE ACCURACY.
7) ALL DIMENSIONS SUBJECT TO MANUFACTURING TOLERANCES OF+/-1/8 [3].

FIGURE 2-4. OUTLINE DIMENSIONS, REMOTE HI-TEMP FLOWMETER WITH ANSI FLANGES

(OD-10D-4127 R2)

OUTLINE DIMENSIONS inches (mm)

DIM	SIZE	1/2 (15)		1 (25)		1-1/2(40)		2 (50)		3 (80)		4 (100)		6 (150)		8 (200)				10 (250)				12 (300)			
	DIN PN	10/16	25/40	10/16	25/40	10/16	25/40	10/16	25/40	10/16	25/40	10/16	25/40	10/16	25/40	10	16	25	40	10	16	25	40	10	16	25	40
	MODEL NO.																										
L	100^S_X3111AD	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	9-7/8 (250)	11 (280)	11-13/16 (300)		13-25/32 (350)				17-23/32 (450)				19-11/16 (500)			
L	100^S_X3111AE	14 (356)		14 (356)		16 (406)		16 (406)		12 (305)		12 (305)		17-23/32 (450)		19-11/16 (500)				21-21/32 (550)				24-13/32 (620)			
	LINER																										
RF	NEOPRENE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RF	OTHERS	1-25/32 (45)		2-11/16 (68)		3-15/32 (88)		4 (102)		5-7/16 (138)		6-7/32 (158)	6-3/8 (162)	8-11/32 (212)	8-19/32 (218)	10-9/16 (268)		10-15/16 (278)	11-7/32 (285)	12-19/32 (320)		13-3/16 (335)	13-19/32 (345)	14-9/16 (370)	14-7/8 (378)	15-9/16 (395)	16-5/32 (410)
B	POLY/NEOP	NA	NA	NA	NA	NA	NA	15/16 (24)	1-1/16 (27)	1-1/8 (28)	1-5/16 (33)	1-1/8 (28)	1-7/16 (36)	1-3/16 (30)	1-5/8 (41)	1-3/8 (35)		1-7/8 (48)		1-7/16 (36)		2-1/8 (54)		NA		NA	
B	TEFL	1/2 (13)	5/8 (16)	11/16 (17)	13/16 (20)	27/32 (21)	31/32 (25)	29/32 (23)	1-1/32 (26)	1-3/32 (27)	1-9/32 (32)	1-3/32 (27)	1-13/32 (35)	1-1/8 (28)	1-9/16 (40)	1-9/32 (33)		1-25/32 (45)		1-3/8 (35)		2-1/16 (52)		1-1/2 (38)		2-1/4 (57)	
B	TEFZ			5/8 (16)	3/4 (19)	3/4 (19)	7/8 (22)	27/32 (21)	31/32 (25)	1-1/16 (27)	1-1/4 (32)	1-1/16 (27)	1-3/8 (35)	1-1/8 (28)	1-9/16 (40)	1-1/4 (32)		1-3/4 (44)		1-5/16 (33)		2 (51)		1-25/64 (36)		2-9/64 (54)	
d		9/16 (14)		9/16 (14)		23/32 (18)		23/32 (18)		23/32 (18)		23/32 (18)	7/8 (22)	7/8 (22)	1-1/32 (26)	7/8 (22)		1-1/32 (26)	1-3/16 (30)	7/8 (22)	1-1/32 (26)	1-3/16 (30)	1-5/16 (33)	7/8 (22)	1-1/32 (26)	1-3/16 (30)	1-5/16 (33)
N		4		4		4		4		8		8		8		8	12	12		12				12			
BC		2-9/16 (65)		3-11/32 (85)		4-11/32 (110)		4-29/32 (125)		6-5/16 (160)		7-3/32 (180)	7-1/2 (190)	9-1/2 (240)	9-27/32 (250)	11-5/8 (295)		12-7/32 (310)	12-19/32 (320)	13-25/32 (550)	13-31/32 (355)	14-9/16 (370)	15-5/32 (385)	15-3/4 (400)	16-9/16 (410)	16-15/16 (430)	17-23/32 (450)
OD		3-3/4 (95)		4-17/32 (115)		5-29/32 (150)		6-1/2 (165)		7-7/8 (200)		8-21/32 (220)	9-1/4 (235)	11-7/32 (285)	11-13/16 (300)	13-3/8 (340)		14-3/16 (360)	14-3/4 (375)	15-9/16 (395)	15-15/16 (405)	16-23/32 (425)	17-23/32 (450)	17-17/32 (445)	18-1/8 (460)	19-3/32 (485)	20-9/32 (515)
A		4-13/16 (122)		4-13/16 (122)		4-13/16 (122)		4-13/32 (112)		4-13/32 (112)		5-1/8 (130)		6-11/16 (170)		7-11/16 (195)				9-27/32 (250)				9-27/32 (250)			
C		2-27/32 (73)		2-27/32 (73)		2-27/32 (73)		3-7/32 (82)		3-7/8 (98)		4-21/32 (118)		5-25/32 (147)		7-1/16 (179)				8-5/32 (207)				9-27/32 (250)			
E		4-17/32 (115)		4-17/32 (115)		4-17/32 (115)		4-7/8 (124)		5-1/2 (140)		6-9/32 (160)		7-1/2 (190)		8-3/4 (222)				9-27/32 (250)				12-9/16 (319)			
F		5-19/32 (142)		5-19/32 (142)		5-19/32 (142)		5-15/16 (150)		6-17/32 (166)		7-5/16 (186)		8-1/2 (216)		9-3/4 (248)				10-7/8 (276)				13-9/16 (345)			
W		6-17/32 (166)		6-17/32 (166)		6-17/32 (166)		7-3/32 (180)		7-7/8 (200)		9-7/16 (240)		12-3/16 (310)		14-3/8 (365)				16-25/32 (426)				20-3/32 (510)			



NOTES
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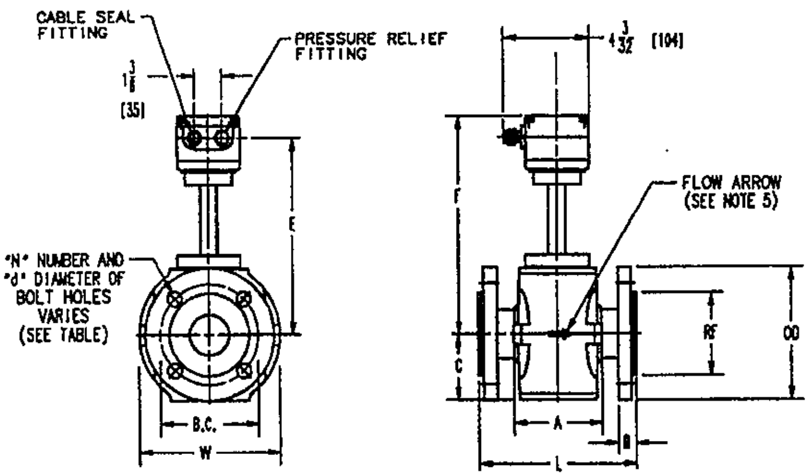
4) FLANGE BOLT HOLES STRADDLE CENTERLINES
5) FLOW MUST BE IN SAME DIRECTION AS FLOW ARROW.
6) METER MUST BE COMPLETELY FILLED WITH LIQUID TO INSURE ACCURACY.
7) ALL DIMENSIONS SUBJECT TO MANUFACTURING TOLERANCES OF +/-1/8 [3] .

FIGURE 2-5. OUTLINE DIMENSIONS, REMOTE CONVERTER WITH DIN FLANGES
(OD-10D-4189 & OD-10D-4230)

OUTLINE DIMENSIONS inches (mm)

DIM	SIZE / DIN PN / MODEL NO.	1/2 (15) 10/16	1/2 (15) 25/40	1 (25) 10/16	1 (25) 25/40	1-1/2 (40) 10/16	1-1/2 (40) 25/40	2 (50) 10/16	2 (50) 25/40	3 (80) 10/16	3 (80) 25/40	4 (100) 10/16	4 (100) 25/40
L	100 S/X 3111AD	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	9-7/8 (250)	11 (280)
L	100 S/X 3111AE	14 (356)		14 (356)		16 (406)		16 (406)		12 (305)		12 (305)	
RF		1-25/32 (45)		2-11/16 (68)		3-15/32 (88)		4 (102)		5-7/16 (138)		6-7/32 (158)	6-3/8 (162)
B		1/2 (13)	5/8 (16)	11/16 (17)	13/16 (20)	27/32 (21)	31/32 (25)	29/32 (23)	1-1/32 (26)	1-3/32 (27)	1-9/32 (32)	1-3/32 (27)	1-13/32 (35)
d		9/16 (14)		9/16 (14)		23/32 (18)		23/32 (18)		23/32 (18)		23/32 (18)	7/8 (22)
N		4		4		4		4		8		8	
BC		2-9/16 (65)		3-11/32 (85)		4-11/32 (110)		4-29/32 (125)		6-5/16 (160)		7-3/32 (180)	7-1/2 (190)
OD		3-3/4 (95)		4-17/32 (115)		5-29/32 (150)		6-1/2 (165)		7-7/8 (200)		8-21/32 (220)	9-1/4 (235)
A		4-13/16 (122)		4-13/16 (122)		4-13/16 (122)		4-13/32 (112)		4-13/32 (112)		5-1/8 (130)	
C		2-27/32 (73)		2-27/32 (73)		2-27/32 (73)		3-7/32 (82)		3-7/8 (98)		4-21/32 (118)	
E		9-9/32 (236)		9-9/32 (236)		9-9/32 (236)		9-5/8 (236)		10-1/4 (260)		11-1/32 (280)	
F		10-11/32 (263)		10-11/32 (263)		10-11/32 (263)		10-11/16 (287)		11-5/16 (287)		12-3/32 (307)	
W		6-17/32 (166)		6-17/32 (166)		6-17/32 (166)		7-3/32 (180)		7-7/8 (200)		9-7/16 (240)	

DIM	SIZE / DIN PN / MODEL NO.	6 (150) 10/16	6 (150) 25/40	8 (200) 10	8 (200) 16	8 (200) 25	8 (200) 40	10 (250) 10	10 (250) 16	10 (250) 25	10 (250) 40	12 (300) 10	12 (300) 16	12 (300) 25	12 (300) 40
L	100 S/X 3111AD	11-13/16 (300)		13-25/32 (350)				17-23/32 (450)				19-11/16 (500)			
L	100 S/X 3111AE	17-23/32 (450)		19-11/16 (500)				21-21/32 (550)				24-13/32 (600)			
RF		8-11/32 (212)	8-19/32 (218)	10-9/16 (268)		10-15/16 (278)	11-7/32 (285)	12-19/32 (320)		13-3/16 (335)	13-19/32 (345)	14-9-16 (320)	14-7/8 (378)	15-9/16 (395)	16-5/32 (410)
B		1-1/8 (28)	1-9/16 (40)	1-9/32 (32)		1-25/32 (45)		1-3/8 (35)		2-1/16 (52)		1-1/2 (38)		2-1/4 (57)	
d		7/8 (22)	1-1/32 (26)	7/8 (22)		1-1/32 (26)	1-3/16 (30)	7/8 (22)	1-1/32 (26)	1-3/16 (30)	1-5/16 (33)	7/8 (22)	1-1/32 (26)	1-3/16 (30)	1-5/16 (33)
N		8		8	12	12		12				12			
BC		9-1/2 (240)	9-27/32 (250)	11-5/8 (295)		12-7/32 (310)	12-19/32 (320)	13-25/32 (350)	13-31/32 (355)	14-9/16 (370)	15-5/32 (385)	15-3/4 (400)	16-9/16 (410)	16-15/16 (430)	17-23/32 (450)
OD		11-7/32 (285)	11-13/16 (300)	13-3/8 (340)		14-3/16 (360)	14-3/4 (375)	15-9/16 (395)	15-15/16 (405)	16-23/32 (425)	17-23/32 (450)	17-17/32 (445)	18-1/8 (460)	19-3/32 (485)	20-9/32 (515)
A		6-11/16 (170)		7-11/16 (195)				9-27/32 (250)				9-27/32 (250)			
C		5-25/32 (147)		7-1/16 (179)				8-5/32 (207)				9-27/32 (250)			
E		12-1/4 (311)		13-1/2 (343)				14-19/32 (371)				16-9/32 (414)			
F		13-5/16 (338)		14-9/16 (370)				15-21/32 (398)				17-5/16 (440)			
W		12-3/16 (310)		14-3/8 (365)				16-25/32 (426)				20-3/32 (510)			



NOTES
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4) FLANGE BOLT HOLES STRADDLE CENTERLINES
5) FLOW MUST BE IN SAME DIRECTION AS FLOW ARROW.
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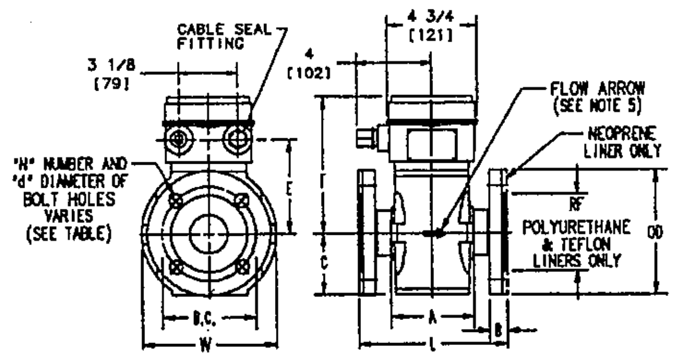
7) ALL DIMENSIONS SUBJECT TO MANUFACTURING TOLERANCES OF +/-1/8 [3].

FIG. 2-6. OUTLINE DIMENSIONS, REMOTE HI-TEMP FLOWMETER WITH DIN FLANGES
(OD-10D-4195 R1 & OD-10D-4232 R0)

OUTLINE DIMENSIONS inches (mm)

DIM	SIZE	1/2 (15)		1 (25)		1-1/2 (40)		2 (50)		3 (80)		4 (100)	
	DIN PN	10/16	25/40	10/16	25/40	10/16	25/40	10/16	25/40	10/16	25/40	10/16	25/40
	MODEL NO.												
L	100 S/X 3111AD	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	9-7/8 (250)	11 (280)
L	100 S/X 3111AE	14 (356)		14 (356)		16 (406)		16 (406)		12 (305)		12 (305)	
	LINER												
RF	NEOPRENE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RF	OTHERS	1-25/32 (45)		2-11/16 (68)		3-15/32 (88)		4 (102)		5-7/16 (138)		6-7/32 (158)	6-3/8 (162)
B	POLY/NEOP	NA	NA	NA	NA	NA	NA	15/16 (24)	1-1/16 (27)	1-1/8 (28)	1-5/16 (33)	1-1/8 (28)	1-7/16 (36)
B	TEFL	1/2 (13)	5/8 (16)	11/16 (17)	13/16 (20)	27/32 (21)	31/32 (25)	29/32 (23)	1-1/32 (26)	1-3/32 (27)	1-9/32 (32)	1-3/32 (27)	1-13/32 (35)
B	TEFZ			5/8 (16)	3/4 (19)	3/4 (19)	7/8 (22)	27/32 (21)	31/32 (25)	1-1/16 (27)	1-1/4 (32)	1-1/16 (27)	1-3/8 (35)
d		9/16 (14)		9/16 (14)		23/32 (18)		23/32 (18)		23/32 (18)		23/32 (18)	7/8 (22)
N		4		4		4		4		8		8	
BC		2-9/16 (65)		3-11/32 (85)		4-11/32 (110)		4-29/32 (125)		6-5/16 (160)		7-3/32 (180)	7-1/2 (190)
OD		3-3/4 (95)		4-17/32 (115)		5-29/32 (150)		6-1/2 (165)		7-7/8 (200)		8-21/32 (220)	9-1/4 (235)
A		4-13/16 (122)		4-13/16 (122)		4-13/16 (122)		4-13/32 (112)		4-13/32 (112)		5-1/8 (130)	
C		2-27/32 (73)		2-27/32 (73)		2-27/32 (73)		3-7/32 (82)		3-7/8 (98)		4-21/32 (118)	
E		4-17/32 (115)		4-17/32 (115)		4-17/32 (115)		4-7/8 (124)		5-1/2 (140)		6-9/32 (160)	
F		6-21/32 (169)		6-21/32 (169)		6-21/32 (169)		7 (178)		7-19/32 (193)		8-3/8 (213)	
W		6-17/32 (166)		6-17/32 (166)		6-17/32 (166)		7-3/32 (180)		7-7/8 (200)		9-7/16 (240)	

DIM	SIZE	6 (150)		8 (200)				10 (250)				12 (300)			
	DIN PN	10/16	25/40	10	16	25	40	10	16	25	40	10	16	25	40
	MODEL NO.														
L	100 S/X 3111AD	11-13/16 (300)		13-25/32 (350)				17-23/32 (450)				19-11/16 (500)			
L	100 S/X 3111AE	17-23/32 (450)		19-11/16 (500)				21-21/32 (550)				24-13/32 (620)			
	LINER														
RF	NEOPRENE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RF	OTHERS	8-11/32 (212)	8-19/32 (218)	10-9/16 (268)		10-15/16 (278)	11-7/32 (285)	12-19/32 (320)		13-3/16 (335)	13-19/32 (345)	14-9/16 (370)	14-7/8 (378)	15-9/16 (395)	16-5/32 (410)
B	POLY/NEOP	1-3/16 (30)	1-5/8 (41)	1-3/8 (35)		1-7/8 (48)		1-7/16 (36)		2-1/8 (54)		NA		NA	
B	TEFL	1-1/8 (28)	1-9/16 (40)	1-9/32 (33)		1-25/32 (45)		1-3/8 (35)		2-1/16 (52)		1-1/2 (38)		2-1/4 (52)	
B	TEFZ	1-1/8 (28)	1-9/16 (40)	1-1/4 (32)		1-3/4 (44)		1-5/16 (33)		2 (51)		1-25/64 (36)		2-9/64 (54)	
d		7/8 (22)	1-1/32 (26)	7/8 (22)		1-1/32 (26)	1-3/16 (30)	7/8 (22)	1-1/32 (26)	1-3/16 (30)	1-5/16 (33)	7/8 (22)	1-1/32 (26)	1-3/16 (30)	1-5/16 (33)
N		8		8	12	12		12				12			
BC		9-1/2 (240)	9-27/32 (250)	11-5/8 (295)		12-7/32 (310)	12-19/32 (320)	13-25/32 (350)	13-31/32 (355)	14-9/16 (370)	15-5/32 (385)	15-3/4 (400)	16-9/16 (410)	16-15/16 (430)	17-23/32 (450)
OD		11-7/32 (285)	11-13/16 (300)	13-3/8 (340)		14-3/16 (360)	14-3/4 (375)	15-9/16 (395)	15-15/16 (405)	16-23/32 (425)	17-23/32 (450)	17-17/32 (445)	18-1/8 (460)	19-3/32 (485)	20-9/32 (515)
A		6-11/16 (170)		7-11/16 (195)				9-27/32 (250)				9-27/32 (250)			
C		5-25/32 (147)		7-1/16 (179)				8-5/32 (207)				9-27/32 (250)			
E		7-1/2 (190)		8-3/4 (222)				9-27/32 (250)				12-9/16 (319)			
F		9-9/16 (243)		10-13/16 (275)				11-15/16 (303)				14-21/32 (372)			
W		12-3/16 (310)		14-3/8 (365)				16-25/32 (426)				20-3/32 (510)			



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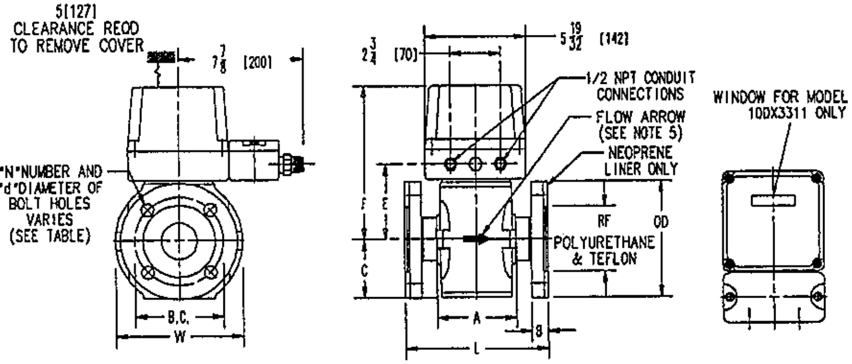
10d4267r0

FIG. 2-8. OUTLINE DIMENSIONS, CONTINUOUS SUBMERGENCE FLOWMETER WITH DIN FLANGES

OUTLINE DIMENSIONS inches (mm)																					
DIM	SIZE	1/2 (15)		1 (25)		1-1/2 (40)		2 (50)		3 (80)		4 (100)		6 (150)		8 (200)		10 (250)		12 (300)	
	ANSI FLG CL	150	300	150	300	150	300	150	300	150	300	150	300	150	300	150	300	150	300	150	300
	MODEL NO.																				
L	10DX 32/33 11AD	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	9-7/8 (250)	11 (280)	11-13/16 (300)		13-25/32 (350)		17-23/32 (450)		19-11/16 (500)	
L	10DX 32/33 11AE	14 (356)		14 (356)		16 (406)		16 (406)		12 (305)		12 (305)		17-23/32 (450)		19-11/16 (500)		21-21/32 (550)		24-13/32 (620)	
L	10DX 32/33 11AF	NA		NA		NA		NA		NA		NA		NA		NA		NA		18 (457)	
	LINER																				
RF	NEOPRENE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RF	OTHERS	1-3/8 (35)		2 (51)		2-7/8 (73)		3-5/8 (92)		5 (127)		6-3/16 (157)		8-1/2 (216)		10-5/8 (270)		12-3/4 (324)		15 (381)	
B	POLY/NEOP	NA	NA	NA	NA	NA	NA	15/16 (24)	1-1/16 (27)	1-3/32 (27)	1-9/32 (32)	1-3/32 (27)	1-7/16 (36)	1-3/16 (30)	1-5/8 (41)	1-5/16 (33)	1-13/16 (46)	1-3/8 (35)	2-1/16 (52)	1-1/2 (38)	2-1/4 (57)
B	TEFLON	1/2 (13)	5/8 (16)	11/16 (17)	13/16 (21)	27/32 (21)	31/32 (25)	29/32 (23)	1-1/32 (26)	1-3/16 (30)	1-3/8 (35)	1-3/32 (27)	1-13/32 (35)	1-1/8 (29)	1-9/16 (40)	1-9/32 (32)	1-25/32 (44)	1-3/8 (35)	2-1/16 (52)	1-1/2 (38)	2-1/4 (57)
B	TEFZEL			5/8 (16)	3/4 (19)	3/4 (19)	7/8 (22)	27/32 (21)	31/32 (25)	1-1/16 (27)	1-1/4 (32)	1-1/16 (27)	1-3/8 (35)	1-1/8 (29)	1-9/16 (40)	1-1/4 (32)	1-3/4 (44)	1-5/16 (33)	2 (51)	1-25/64 (35)	2-9/64 (54)
d		5/8 (16)		5/8 (16)	3/4 (19)	5/8 (16)	7/8 (22)	3/4 (19)	3/4 (19)	3/4 (19)	7/8 (22)	3/4 (19)	7/8 (22)	7/8 (22)	7/8 (22)	7/8 (22)	1 (25)	1 (25)	1-1/8 (29)	1 (25)	1-1/8 (29)
N		4	4	4	4	4	4	4	8	4	8	8	8	8	12	8	12	12	16	12	16
BC		2-3/8 (60)	2-5/8 (67)	3-1/8 (79)	3-1/2 (89)	3-7/8 (98)	4-1/2 (114)	4-3/4 (121)	5 (127)	6 (152)	6-5/8 (168)	7-1/2 (191)	7-7/8 (200)	9-1/2 (241)	10-5/8 (270)	11-3/4 (298)	13 (330)	14-1/4 (362)	15-1/4 (387)	17 (432)	17-3/4 (451)
OD		3-1/2 (89)	3-3/4 (95)	4-1/4 (108)	4-7/8 (124)	5 (127)	6-1/8 (156)	6 (152)	6-1/2 (165)	7-1/2 (190)	8-1/4 (210)	9 (229)	10 (254)	11 (279)	12-1/2 (318)	13-1/2 (343)	15 (381)	16 (406)	17-1/2 (445)	19 (483)	20-1/2 (521)
A		4-13/16 (122)		4-13/16 (122)		4-13/16 (122)		4-13/32 (112)		4-13/32 (112)		5-1/8 (130)		6-11/16 (170)		7-11/16 (195)		9-27/32 (250)		9-27/32 (250)	
C		2-27/32 (73)		2-27/32 (73)		2-27/32 (73)		3-7/32 (82)		3-7/8 (98)		4-21/32 (118)		5-25/32 (147)		7-1/16 (179)		8-5/32 (207)		9-27/32 (250)	
E		3-27/32 (98)		3-27/32 (98)		3-27/32 (98)		4-7/32 (107)		4-27/32 (123)		5-5/8 (143)		4-13/32 (173)		8-3/32 (205)		9-3/16 (233)		12-9/16 (319)	
F		7-29/32 (201)		7-29/32 (201)		7-29/32 (201)		8-1/2 (216)		9-1/8 (232)		9-29/32 (252)		10-7/8 (276)		12-1/8 (308)		13-1/4 (336)		13-19/32 (345)	
W		6-17/32 (166)		6-17/32 (166)		6-17/32 (166)		7-3/32 (180)		7-7/8 (200)		9-7/16 (240)		12-3/16 (310)		14-3/8 (365)		16-25/32 (426)		20-5/64 (510)	



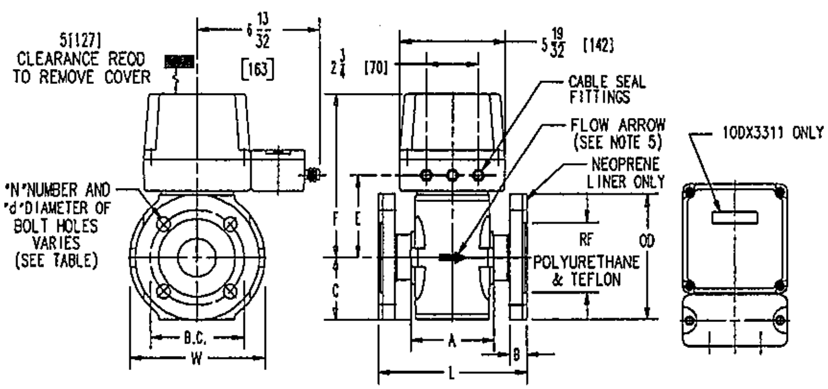
NOTES
1) ALL DIMENSIONS ARE IN INCHES. DIMENSIONS IN PARENTHESIS [ ] ARE IN MILLIMETERS [mm].
2) DIMENSIONS ARE GUARANTEED ONLY IF THIS PRINT IS CERTIFIED.
3) THIS DRAWING IS A THIRD ANGLE PROJECTION AS SHOWN.
4) FLANGE BOLT HOLES STRADDLE CENTERLINES
5) FLOW MUST BE IN SAME DIRECTION AS FLOW ARROW.
6) METER MUST BE COMPLETELY FILLED WITH LIQUID TO INSURE ACCURACY.
7) ALL DIMENSIONS SUBJECT TO MANUFACTURING TOLERANCES OF ±1/8 [3].

FIG. 2-9. OUTLINE DIMENSIONS, INTEGRAL CONVERTER WITH ANSI FLANGES
(OD-10D-4124, R1)

OUTLINE DIMENSIONS inches (mm)

DIM	SIZE / DIN PN / MODEL NO. / LINER	1/2 (15) 10/16	1/2 (15) 25/40	1 (25) 10/16	1 (25) 25/40	1-1/2 (40) 10/16	1-1/2 (40) 25/40	2 (50) 10/16	2 (50) 25/40	3 (80) 10/16	3 (80) 25/40	4 (100) 10/16	4 (100) 25/40	6 (150) 10/16	6 (150) 25/40
L	10DX$^{32}_{33}$11AD	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	7-7/8 (200)	9 (229)	9-7/8 (250)	11 (280)	11-13/16 (300)	
L	10DX$^{32}_{33}$11AE	14 (356)		14 (356)		16 (406)		16 (406)		12 (305)		12 (305)		17-23/32 (450)	
RF	NEOPRENE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RF	OTHERS	1-25/32 (45)		2-11/16 (68)		3-15/32 (88)		4 (102)		5-7/16 (138)		6-7/32 (158)	6-3/8 (162)	8-11/32 (212)	8-19/32 (218)
B	POLY/NEOP	NA	NA	NA	NA	NA	NA	15/16 (24)	1-1/16 (27)	1-1/8 (28)	1-5/16 (33)	1-1/8 (28)	1-7/16 (36)	1-3/16 (30)	1-5/8 (41)
B	TEFL	1/2 (13)	5/8 (16)	11/16 (17)	13/16 (20)	27/32 (21)	31/32 (25)	29/32 (23)	1-1/32 (26)	1-3/32 (27)	1-9/32 (32)	1-3/32 (27)	1-13/32 (35)	1-1/8 (29)	1-9/16 (40)
B	TEFZ			5/8 (16)	3/4 (16)	3/4 (16)	7/8 (22)	27/32 (21)	31/32 (25)	1-1/16 (27)	1-1/4 (32)	1-1/16 (27)	1-3/8 (35)	1-1/8 (28)	1-9/16 (40)
d		9/16 (14)		9/16 (14)		23/32 (18)		23/32 (18)		23/32 (18)		23/32 (18)	7/8 (22)	7/8 (22)	1-1/32 (26)
N		4		4		4		4		8		8		8	
BC		2-9/16 (65)		3-11/32 (85)		4-11/32 (110)		4-29/32 (125)		6-5/16 (160)		7-3/32 (180)	7-1/2 (190)	9-1/2 (240)	9-27/32 (250)
OD		3-3/4 (95)		4-17/32 (115)		5-29/32 (150)		6-1/2 (165)		7-7/8 (200)		8-21/32 (220)	9-1/4 (235)	11-7/32 (285)	11-13/16 (300)
A		4-13/16 (122)		4-13/16 (122)		4-13/16 (122)		4-13/32 (112)		4-13/32 (112)		5-1/8 (130)		6-11/16 (170)	
C		2-27/32 (73)		2-27/32 (73)		2-27/32 (73)		3-7/32 (82)		3-7/8 (98)		4-21/32 (118)		5-25/32 (147)	
E		3-27/32 (98)		3-27/32 (98)		3-27/32 (98)		4-7/32 (107)		4-27/32 (123)		5-5/8 (143)		4-13/32 (173)	
F		7-29/32 (201)		7-29/32 (201)		7-29/32 (201)		8-1/2 (216)		9-1/8 (232)		9-29/32 (252)		10-7/8 (276)	
W		6-17/32 (166)		6-17/32 (166)		6-17/32 (166)		7-3/32 (180)		7-7/8 (200)		9-7/16 (240)		12-3/16 (310)	

DIM	SIZE / DIN PN / MODEL NO. / LINER	8 (200) 10	8 (200) 16	8 (200) 25	8 (200) 40	10 (250) 10	10 (250) 16	10 (250) 25	10 (250) 40	12 (300) 10	12 (300) 16	12 (300) 25	12 (300) 40
L	10DX$^{32}_{33}$11AD	13-25/32 (350)				17-23/32 (450)				19-11/16 (500)			
L	10DX$^{32}_{33}$11AE	19-11/16 (500)				21-21/32 (550)				24-13/32 (620)			
RF	NEOPRENE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RF	OTHERS	10-9/16 (268)		10-15/16 (278)	11-7/32 (285)	12-19/32 (320)		13-3/16 (335)	13-19/32 (345)				
B	POLY/NEOP	1-3/8 (35)		1-7/8 (48)		1-7/16 (36)		2-1/8 (54)		NA		NA	
B	TEFL	1-9/32 (33)		1-25/32 (45)		1-3/8 (35)		2-1/16 (52)		1-1/2 (38)		2-1/4 (57)	
B	TEFZ	1-1/4 (32)		1-3/4 (44)		1-5/16 (33)		2 (51)		1-25/64 (35)		2-9/64 (54)	
d		7/8 (22)		1-1/32 (26)	1-3/16 (30)	7/8 (22)	1-1/32 (26)	1-3/16 (30)	1-5/16 (33)	7/8 (22)	1-1/32 (26)	1-3/16 (30)	1-5/16 (33)
N		8	12	12		12				12			
BC		11-5/8 (295)		12-7/32 (310)	12-19/32 (320)	13-25/32 (350)	13-31/32 (355)	14-9/16 (370)	15-5/32 (385)	15-3/4 (400)	16-9/16 (410)	16-15/16 (430)	17-23/32 (450)
OD		13-3/8 (340)		14-3/16 (360)	14-3/4 (375)	15-9/16 (395)	15-15/16 (405)	16-23/32 (425)	17-23/32 (450)	17-17/32 (445)	18-1/8 (460)	19-3/32 (485)	20-9/32 (515)
A		7-11/16 (195)				9-27/32 (250)				9-27/32 (250)			
C		7-1/16 (179)				8-5/32 (207)				9-27/32 (250)			
E		8-3/32 (205)				9-3/16 (233)				12-9/16 (319)			
F		12-1/8 (308)				13-1/4 (336)				13-19/32 (345)			
W		14-3/8 (365)				16-25/32 (426)				20-3/32 (510)			



NOTES
1) ALL DIMENSIONS ARE IN INCHES. DIMENSIONS IN PARENTHESIS [ ] ARE IN MILLIMETERS [mm].
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4) FLANGE BOLT HOLES STRADDLE CENTERLINES
5) FLOW MUST BE IN SAME DIRECTION AS FLOW ARROW.
6) METER MUST BE COMPLETELY FILLED WITH LIQUID TO INSURE ACCURACY.
7) ALL DIMENSIONS SUBJECT TO MANUFACTURING TOLERANCES OF +/-1/8 [3] .

FIG. 2-10. OUTLINE DIMENSIONS, INTEGRAL CONVERTER WITH DIN FLANGES
(OD-10D-4189 & OD-10D-4230)

2.4 Mounting

2.4.1 Orientation

The Fischer & Porter Series 3000 Magnetic Flowmeter may be installed in horizontal, vertical or sloping pipe runs. However, precautions must be taken to assure that the metering tube is filled at all times during measurement. A vertical installation, with the pipe line carrying liquid upwards assures a filled hydraulic line under low flow rate conditions and also minimizes wear on the meter lining by abrasive grit. Horizontal installations should be made with the meter in the lower section of a pipeline to assure a filled meter condition.

For horizontal or sloping installations the meter should be placed so that the electronic housing of the meter is on top. This will align the meter electrodes in a lateral plane. Positioning the meter in this way eliminates the possibility of entrained air acting as an electrode insulator.

The Magnetic Flowmeter must be oriented in accordance with the direction of process flow, as indicated by the FLOW arrow on the meter body. For accurate metering, a straight pipe run equivalent to a minimum of three straight pipe diameters are required upstream of the magmeter for elbows and tees, measured from the center of the meter (refer to Figure 2-11).

If a control valve is required, it is recommended that it be placed downstream of the meter. Upstream valves can create turbulence that result in air pockets and may affect the meter's accuracy or cause its output to be noisy. A minimum of ten pipe diameters of straight pipe are required upstream between the magmeter and a control valve or pump (refer to Figure 2-11).

2.4.2 Meter Handling

The liner of the Flowmeter must be protected at all times. The liner can be damaged by sharp objects or cut by undue pressure. The protective covers provide protection for the liner. Keep the covers in place until the Primary is actually ready for installation. Once the protective covers are removed during installation, be careful not to damage the liner with the mating flanges in order to avoid potential process leaks. Do not pass any rope or wire sling through the meter liner (Refer to Figure 2-2 for proper hoisting method).

NOTE
Leave metal protector plates or plywood lining protectors in place on the meter until the meter is ready to be installed, otherwise the Teflon meter liner will have a tendency to "flare" away from the meter face and may make meter installation difficult.

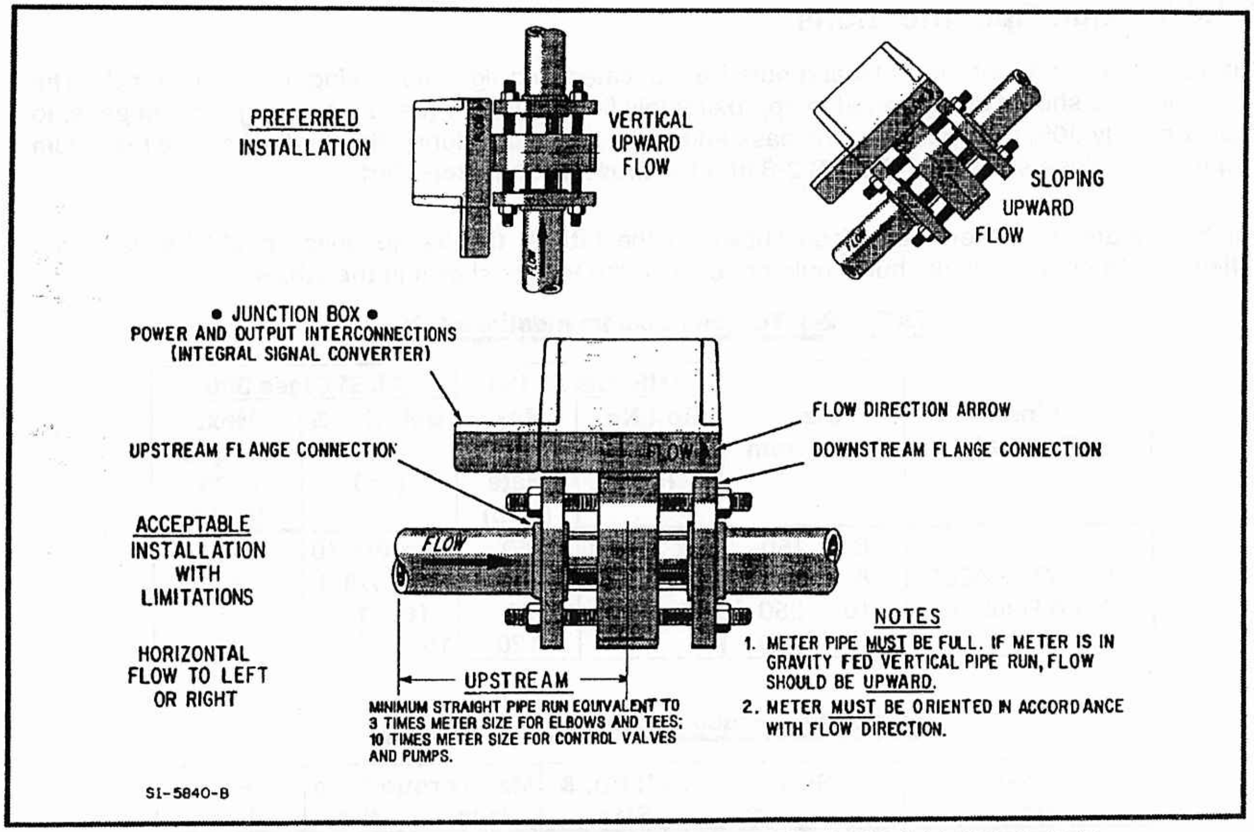


FIGURE 2-11. RECOMMENDED PIPING ARRANGEMENT

2.4.3 Pipe Connections

The TEFLON, TEFZEL and polyurethane lined meters have raised faced flanges rated as specified. The neoprene and hard-rubber lined meters have full faced flanges rated as specified. Two flange gaskets are supplied per meter; the mounting studs and nuts are furnished by the user.

Flange nuts should be tightened in an alternate pattern (e.g., 1-3, 2-4) as shown in Figure 2-12 to produce equal pressure distribution around the flange face. Bolt torque should be limited to the values shown in Tables 2-1 & 2-2. For TEFLON-lined meters, the bolt-torque must be sufficient to force the flared liner flat against the flange's raised face.

Refer to Figure 2-11 for recommended piping arrangement.

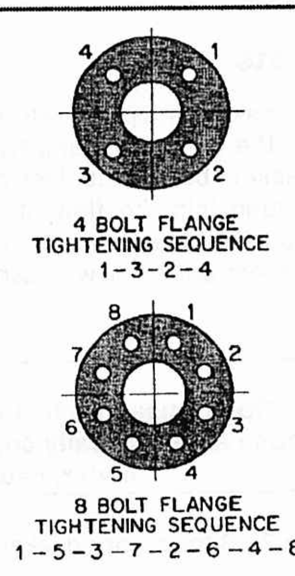


FIGURE 2-12. BOLT TIGHTENING SEQUENCE

2.4.4 Torque Specifications

It is recommended that the bolts and nuts be lubricated and tightened using a torque wrench. The bolts and nuts should be tightened to approximately 50% of the torque value during the first pass, to approximately 80% during the second pass and to the full torque during the third pass. The maximum torque rate values shown in TABLES 2-3 and 2-4 **must not be exceeded.**

For liner materials other than those shown in the tables, the flange bolts should be tightened sufficiently to stop any leaks but should not exceed the values shown in the tables.

TABLE 2-3. Torque Recommendations (ANSI)

Liner Material	Size in.	Size mm	ANSI Class 150 Bolt No. & Size (in.)	ANSI Class 150 Max. Torque Rate (ft-lb)	ANSI Class 300 Bolt No. & Size (in.)	ANSI Class 300 Max. Torque Rate (ft-lb)
PTFE/TEFZEL/ Hard Rubber	6	150	8 x 3/4-10	60	12 x 3/4-10	40
	8	200	"	85	12 x 7/8-9	60
	10	250	12 x 7/8-9	90	16 x 1-8	65
	12	300	"	120	16 x 1 1/8-7	95

TABLE 2-4. Torque Recommendations (DIN)

Liner Material	Size in.	Size mm	Bolt No. & Size	Max.Torque Rate ft-lb	Max.Torque Rate Nm	PN bar
PTFE/ Hard Rubber	6	150	8 x M20	60.8	82.5	16
	8	200	12 x M20	59.7	81.0	16
	10	250	12 x M24	88.5	120.0	16
	12	300	12 x M24	118.0	160.0	16

2.4.5 Gaskets

Use only the gaskets supplied with the instrument. The gaskets supplied with the meter are the proper size for the meter size and type specified. When installing the meter it is important that the correct size gaskets be utilized. Use of the wrong size gaskets could allow the inner diameter of the gasket to protrude into the flow stream, thereby altering the flow profile within the meter. This condition could affect meter accuracy significantly and must be avoided. Using the proper gaskets and installing them correctly will also avoid any possibility of leakage. Observe parts information given in Section 6.0.

NOTE
Do not use graphite gaskets. Under certain conditions they may cause an electrically conductive layer to form on the inside wall of the meter, causing meter operation to degrade.

Refer to Figure 2-13 for proper gasket locations.

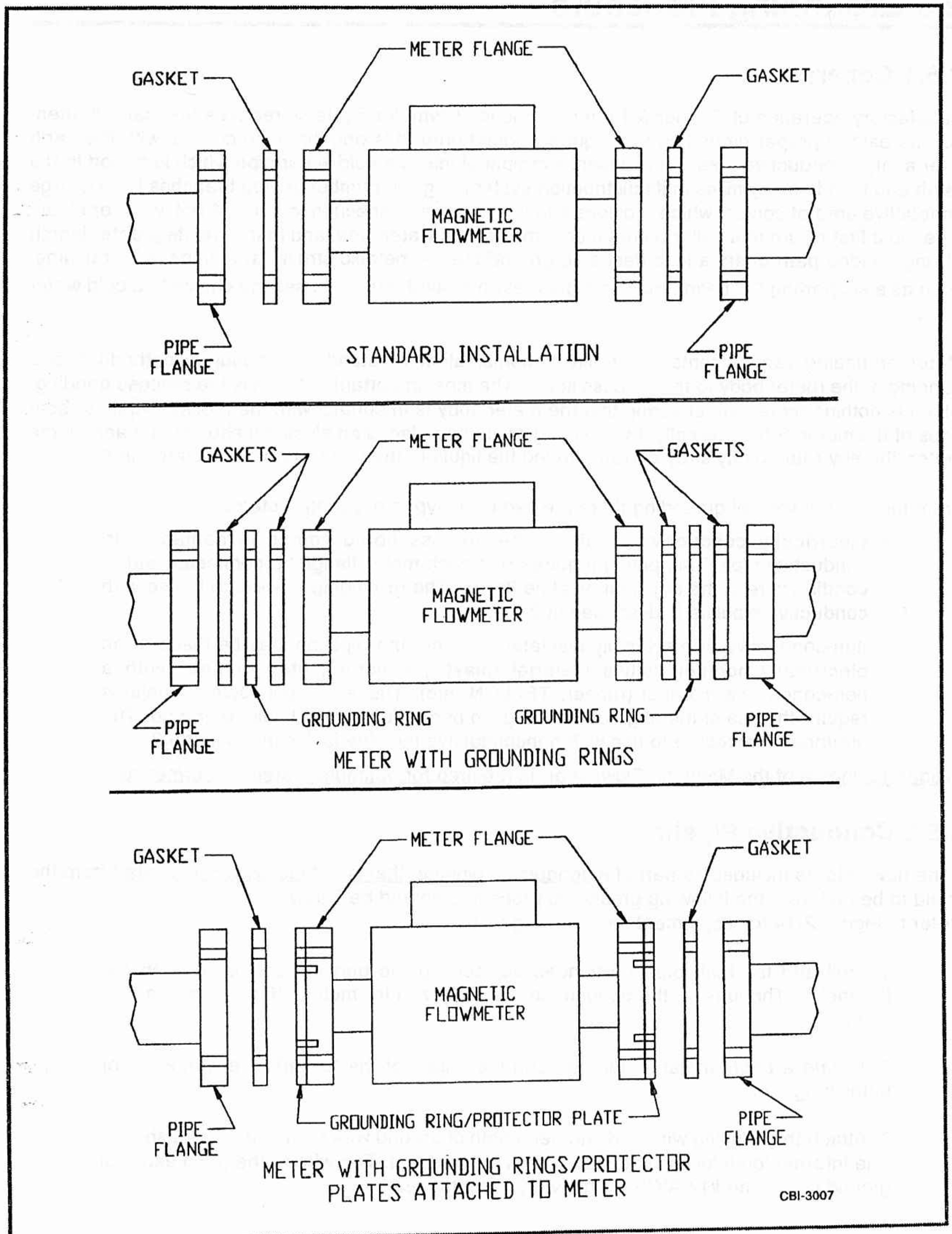


FIGURE 2-13 . GASKET LOCATIONS

2.5 Grounding Procedure

2.5.1 General

Satisfactory operation of Fischer & Porter Magnetic Flowmeter Systems requires that careful attention be paid to proper grounding techniques. A good ground is one that is in contact with the earth over a large conductive area. An excellent example of this is a cold water pipe which is buried in the earth and travels many miles in its distribution system. A great number of pipe branches form a large conductive area of contact which provides a low resistance connection to earth. A hot water or steam pipe must first return to a boiler before it becomes a cold water pipe, and therefore, its greater length of ungrounded path offers a less desirable ground bus. A metallic structural member of a building, such as a supporting "I" beam, may be a good earth ground, but it is a second choice to a cold water pipe.

Meter grounding requirements are really a combination of standard grounding methods and a bonding of the meter body to the process liquid. The most important of these is the process bonding, which is nothing more than ensuring that the meter body is in contact with the process liquid at both ends of the meter body. Basically, the bonding procedure places an electrical short circuit across the meter, thereby routing any stray current around the liquid in the meter (rather than through it).

From the point of view of grounding there are two basic types of piping systems:

- electrically conductive pipeline: the process liquid comes in contact with conductive pipe. This piping requires that each meter flange be connected with a bonding wire to the adjacent pipeline flange. The grounding procedure to use with conductive pipeline is described in 2.5.2.
- non-conductive or electrically insulated pipeline: the pipeline may be made of an electrically non-conductive material (plastic, concrete, etc.) or lined with a non-conductive material (rubber, TEFLON, etc). These non-conductive pipelines require the use of metal grounding rings to bond the process liquid to ground. The grounding procedure to use with nonconductive pipeline is described in 2.5.3.

Proper grounding of the Magnetic Flowmeter is required for optimum system performance.

2.5.2 Conductive Pipeline

If the flowmeter is included as part of a conductive pipeline that is not electrically insulated from the liquid to be metered, the following grounding procedure should be followed.
Refer to Figure 2-14 to supplement the following text.

1) Drill and tap both pipeline flanges adjacent to the bonding connections on the flowmeter. The lugs on the bonding cables are sized for metric M6 fasteners (a 1/4" bolt).

2) Obtain a bright metal surface around the edges of the tapped hole with a file or burnishing tool.

3) Attach the bonding wire and another length of ground wire to the flanges as shown. Use internal tooth lockwashers as shown in the detail. The wire to the good external ground should be #12 AWG, or heavier, copper wire.

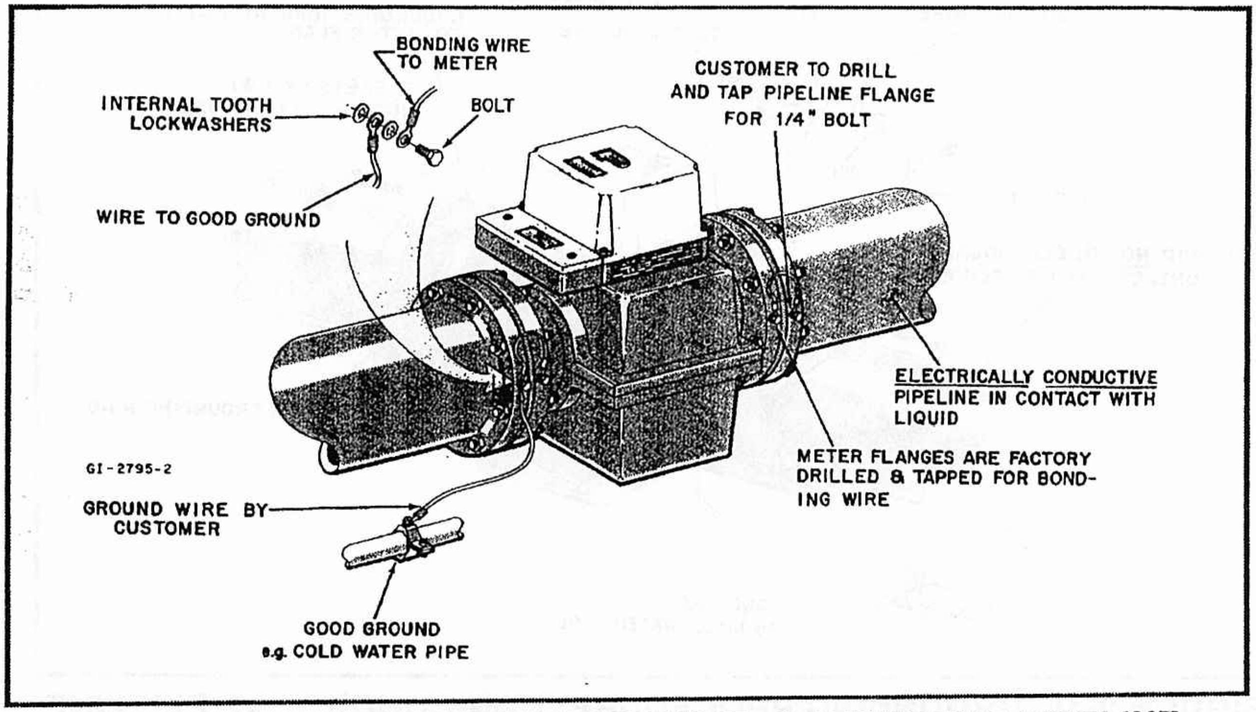


FIGURE 2-14. GROUNDING PROCEDURE; CONDUCTIVE PIPELINE

Note that the flowmeter shown in this illustration is not the meter described in this instruction bulletin

2.5.3 Non-Conductive or Electrically Insulated Pipeline

If the flowmeter is included as part of a non-conductive or liquid insulated pipeline (such as totally plastic pipe, ceramic lined iron pipe, or cast pipe with internal bitumastic coating), the following grounding procedures apply. Refer to Figure 2-15 to supplement the following text.

1) For this service, the meter requires the use of grounding rings. The grounding rings should be installed between the meter flanges and the mating flanges of the pipeline as shown in Figure 2-15. A gasket is required on both sides of the grounding ring (see NOTE below). If the meter is supplied with a grounding ring/protector plate fastened to the meter flange,only one gasket is required between the grounding ring/protector plate and the pipeline flange. Proper gasket locations are shown in Figure 2-13.

> **NOTE**
> **When using grounding rings and gaskets, add 1/8 inch per end (1/4 inch total) to the overall meter installation length (dimension "L" in Figures 2-3 through 2-10) to allow for the added thickness of these items.**

2) Attach the bonding wire and ground wire to the tab of the grounding ring. Use internal tooth lockwashers and hex head nut and bolts as shown in Figure 2-15. The ground wire should be #12 AWG, or heavier, copper wire.

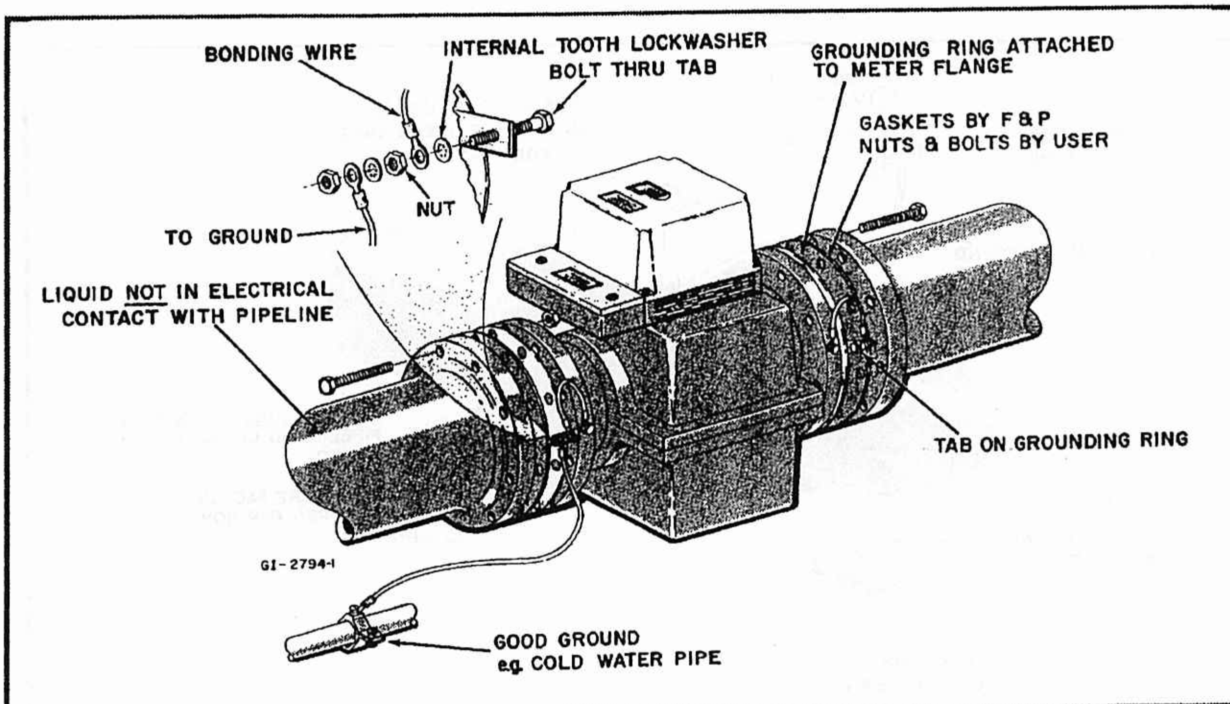


FIGURE 2-15. GROUNDING PROCEDURE; NON-CONDUCTIVE PIPELINE

Note that the flowmeter shown in this illustration is not the meter described in this instruction bulletin.

2.6 Electrical Interconnection

The Series 3000 Magnetic Flowmeter may be furnished with either an integrally or optional remotely mounted Signal Converter. Interconnection wiring is arranged differently for the two systems. Interconnection details are provided in the Instruction Bulletin provided with the Signal Converter.

WARNING
ELECTRICAL SHOCK HAZARD. Equipment powered by ac line voltage constitutes a potential electric shock hazard to the user. Make certain that the system power input leads are disconnected from the operating branch circuit before attempting electrical interconnections.

Regardless of the interconnection procedure used, the grounding procedures given in Section 2.5 must be followed.

For explosion proof meter installation, all interconnection wiring must be installed according to National Electrical Code (NEC) ANSI/NFPA 70 Section 500.

NOTE
For meters capable of continuous submergence, the signal cable has been permanently installed by the factory. Do not loosen the cable seal fitting or remove the connection box lid since this will break the seal and void the warranty.

2.7 Conduit Seal and Pressure Relief

In accordance with the National Electrical Code (NEC) ANSI/NFPA 70, Article 501-5(f)(3), the flowmeters include a conduit entry seal and pressure relief to prevent the process fluid from entering the electrical conduit system. This safety feature is available for NPT fittings only and considers the remote possibility of a primary seal failure, in which case the secondary seal will prevent the process from entering the electrical conduit system. The secondary seal consists of the following:

- Integral Converter - Feed-through's between the electronics housing and field wiring (customer connection) junction box.
- Remote Primary - Conduit entry cable seal on meter customer connection box.

It is the user's responsibility to properly install the conduit entry cable seal fitting supplied with the signal cable provided with the remote mounted signal converter. This will ensure proper performance of this safety feature. See Figure 2-16.

The electronics housing for the integrally mounted signal converter contains an integral pressure relief system while the customer connection box on the remote mounted flowmeter contains a pressure-relief valve. In the unlikely event that the primary seal should fail, the pressure relief mechanism will vent the process, preventing a potentially dangerous over pressurization and possible failure of the electronics housing. This feature is not necessary and, consequently is not provided, on explosion-proof or continuously submersible models.

It is the user's responsibility to be aware of this safety feature, when provided, and to consider the unlikely event of its functioning. Based on knowledge of the process and meter application, the user should consider the installation orientation of the meter and possible use of deflectors to safely direct the vented process.

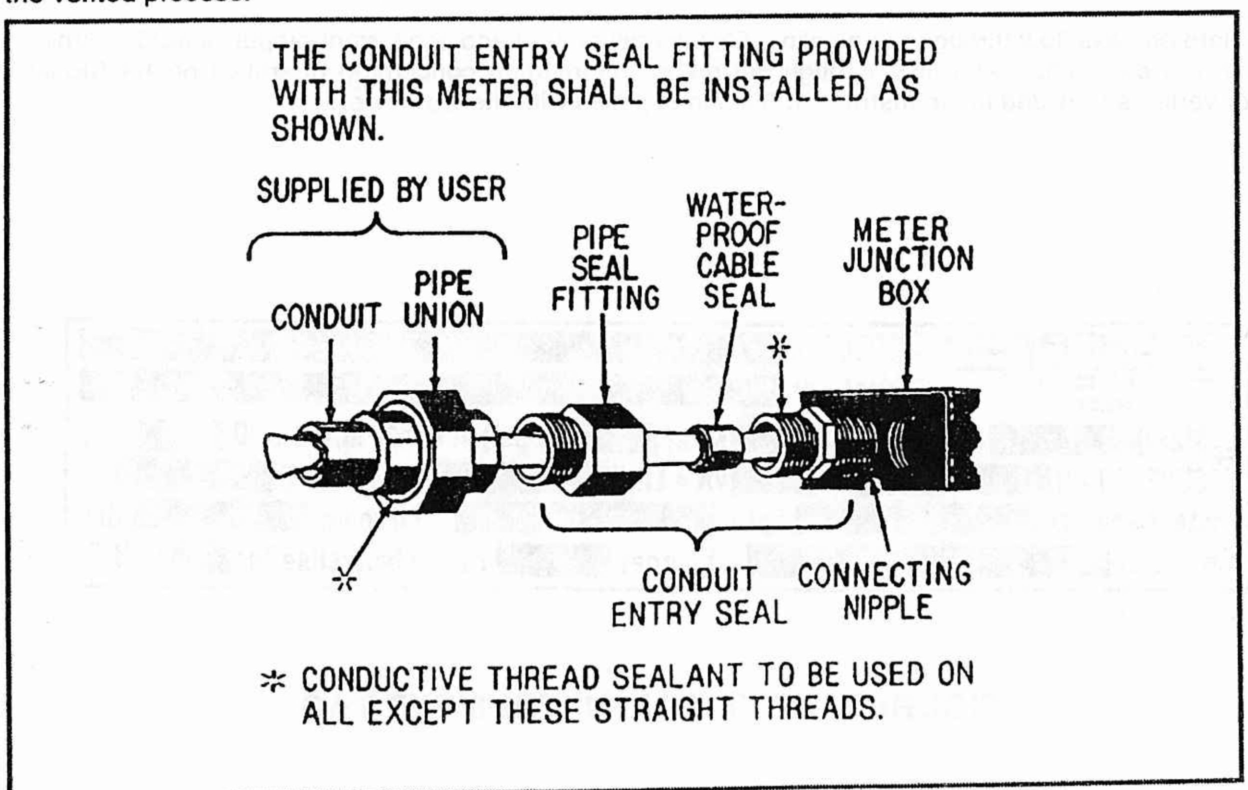


FIGURE 2-16. CONDUIT ENTRY SEAL INSTALLATION

3.0 START-UP and OPERATION

The Fischer & Porter Series 3000 Magnetic Flowmeter (which includes the integral or remote Signal Converter) is precision calibrated at the factory. Each Flowmeter is calibrated to determine its meter capacity at a given velocity. Refer to Table 1-4.

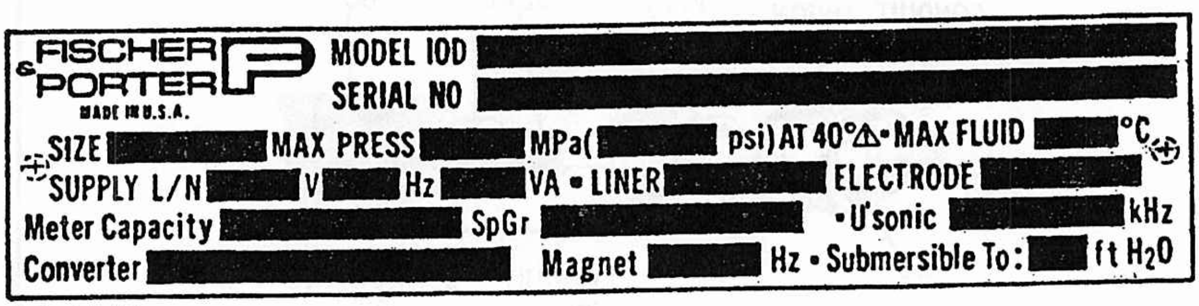
There are no operating controls that require field adjustment unless the full scale range setting was not specified. If a change in the full scale range setting is required, refer to the Instruction Bulletin supplied with the Signal Converter. If no change is required, the equipment is ready for operation as received.

Prior to initial system start up, verify that the meter is properly installed; check flow direction, wiring interconnection and grounding as discussed in Section 2.0 Installation. Particular attention should be given to the meter grounding procedures; improper grounding may result in unsatisfactory performance. Refer to the Signal Converter Instruction Bulletin for interconnection grounding.

Start flow through the process piping system that includes the meter. Allow a nominal flow through the pipeline for several minutes to purge entrapped air. The pipeline must be full for accurate flow measurement.

Apply the appropriate power for the 10DX3111 Magnetic Flowmeter by closing the external switch or circuit breaker; there are no switches inside of the equipment. Also energize any auxiliary equipment associated with the flow metering system, such as remote analog recorders, controllers or rate indicators.

Initiate process flow through the pipeline. Flow measurement and concurrent output signal transmission will commence with flow through the meter. Information concerning operation of the Signal Converter is provided in the Instruction Bulletin supplied with the Converter.



SI- 7143

FIGURE 3-1. TYPICAL INSTRUMENT TAG

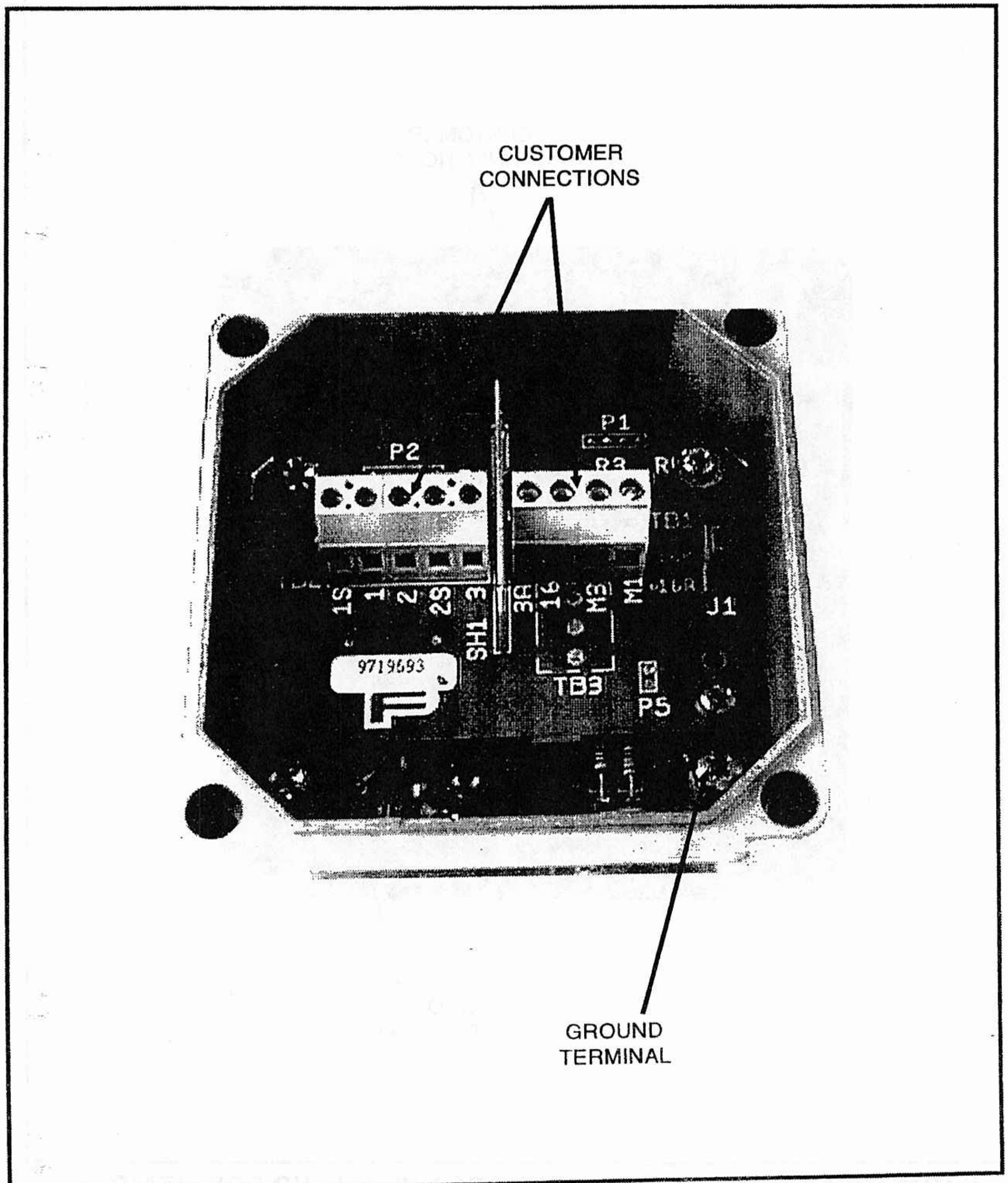


FIGURE 3-2. 10DX3111A PRIMARY CONNECTIONS FOR REMOTE MOUNTED SIGNAL CONVERTER

Note: The assembly shown is a "typical" assembly and may not represent the configuration of your specific model. Newer models may be different from the configuration shown.

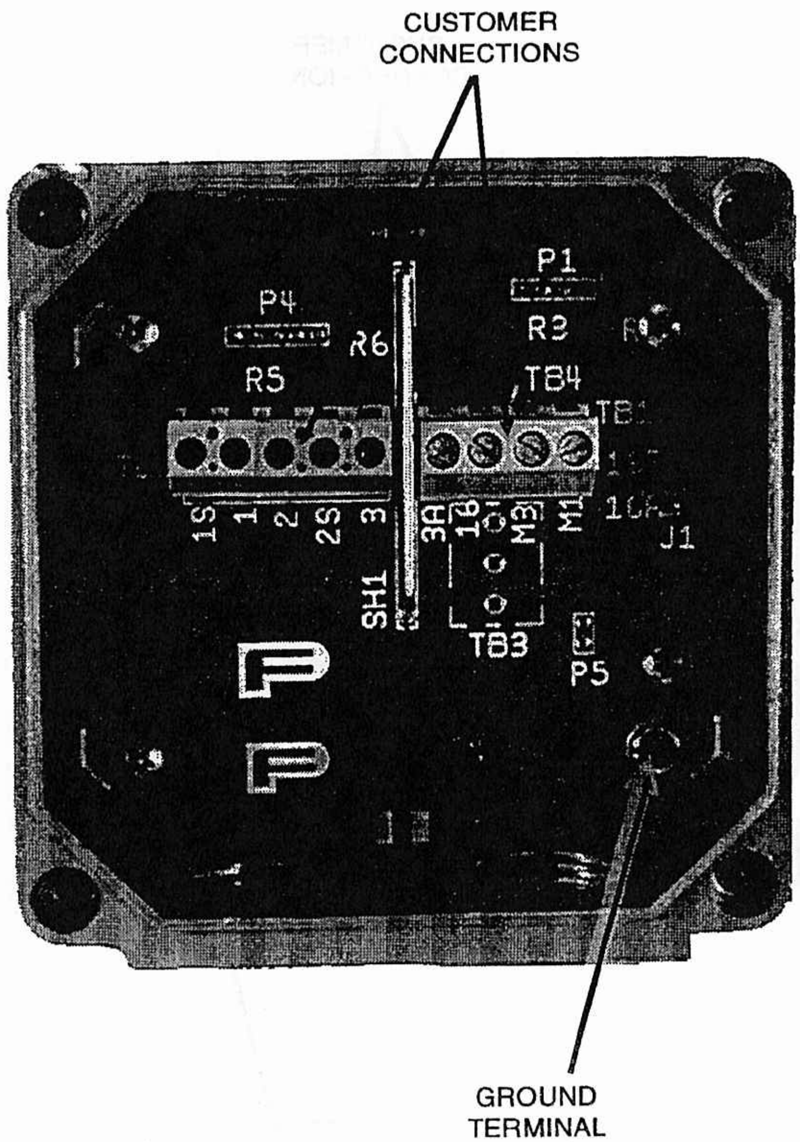


FIGURE 3-3. 10DX3111G PRIMARY CONNECTIONS FOR REMOTE MOUNTED SIGNAL CONVERTER

Note: The assembly shown is a "typical" assembly and may not represent the configuration of your specific model. Newer models may be different from the configuration shown.

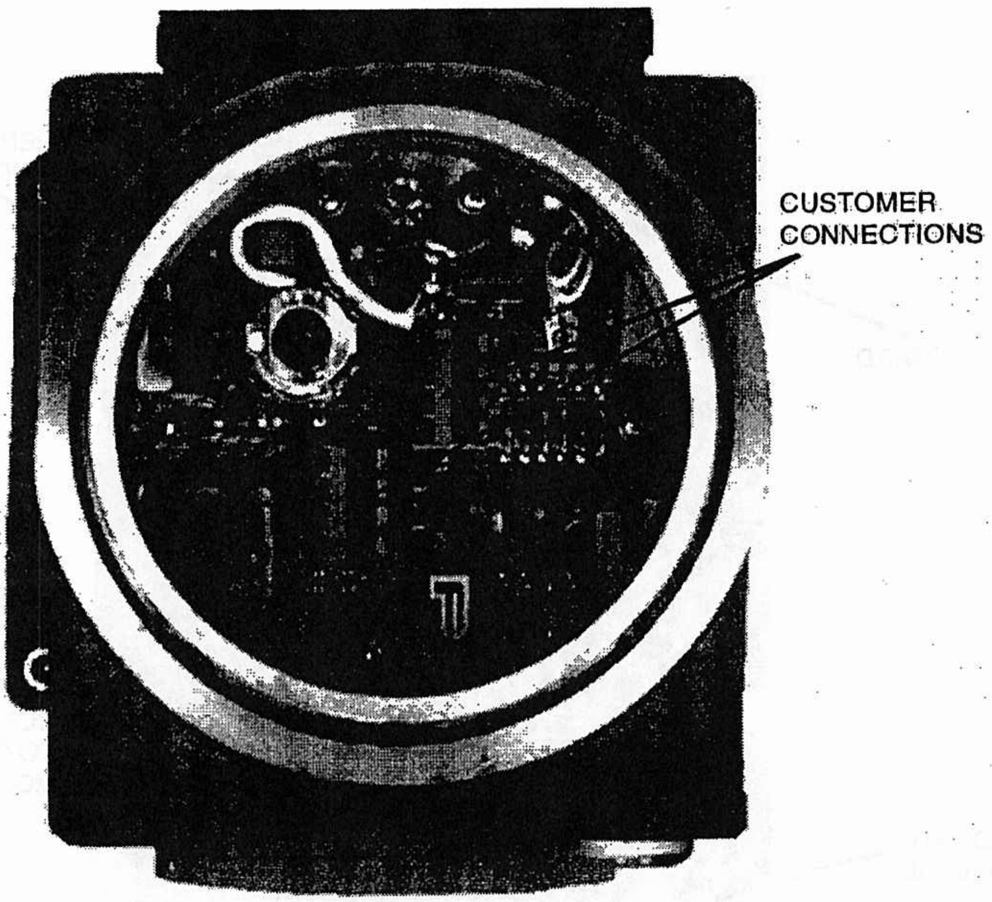


FIGURE 3-4. CONTINUOUS SUBMERGENCE PRIMARY CONNECTIONS FOR REMOTE MOUNTED SIGNAL CONVERTER

Note: Figure shows electronics without encapsulation material. Normally the converter housing is filled with a silicone rubber encapsulant.

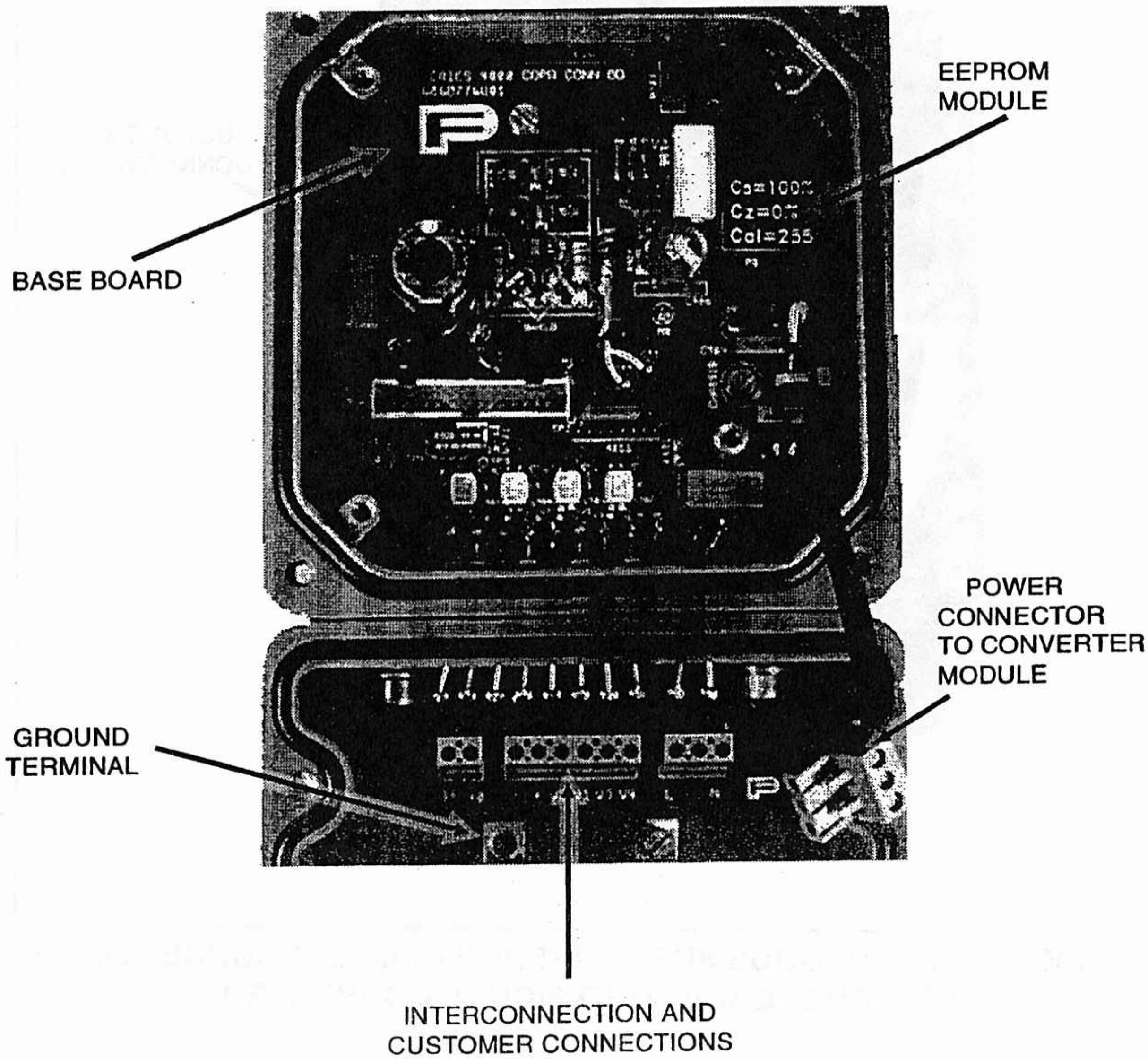


FIGURE 3-5. 10DX3311G INTEGRALLY MOUNTED M2 SIGNAL CONVERTER (SHOWN WITHOUT CONVERTER MODULE)

Note: The assembly shown is a "typical" assembly and may not represent the configuration of your specific model. Newer models may be different from the configuration shown.

4.0 FUNCTIONAL DESCRIPTION

The Magnetic Flowmeter body houses two signal electrodes and two flux producing magnet coils, as shown schematically in Figure 4-1. All primary intraconnection wiring is terminated at a printed circuit assembly located in the base mounted on the meter housing.

Primary models 10DX3111A provides two output signals to the associated Signal Converter:

- two electrode signals that contain the flow rate information
- the reference voltage signal which is proportional to the magnet excitation current and the flux density in the metering section

The reference voltage is derived across a precision constant meter capacity (CMC) resistance network that is connected in series with the magnet coils. Changes in magnet drive voltage, which cause a variation of flow signal, will simultaneously cause a proportional variation of the reference voltage. The Converter's measurement circuitry will calculate an exact ratio and thereby provide immunity to power supply variation. The magnet coil drive circuitry is contained in the Signal Converter.

Primary Models 10DX3111G also provide the above two electrode signals to the Signal Converter and also have provision for connecting a pair of coil excitation wires from the Converter. A reference voltage, as described above for the 10DX3111A model, is not developed in the Model 10DX3111G Primaries.

4.1 Basic Operating Principle

4.1.1 Signal Voltage Generation

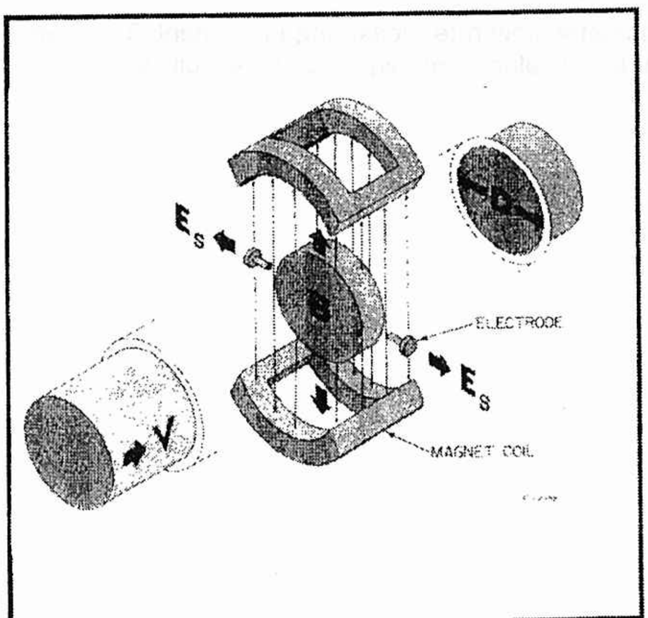


FIGURE 4-1. BASIC OPERATING PRINCIPLE

The operating principle of the Fischer & Porter Series 3000 Magnetic Flowmeter is based upon Faraday's Law of Induction which states that the voltage induced across any conductor as it moves at right angles through a magnetic field will be proportional to the velocity of that conductor. This principle finds common application in direct and alternating current generators. Essentially, the Fischer & Porter Magnetic Flowmeter constitutes a modified form of a generator.

Figure 4-1 graphically illustrates the basic operating principle. A magnetic field, "B", being generated in planes which are perpendicular to the axis of the meter pipe. A disk of the metered liquid can be considered as a conductor. The transverse length "D" is equal to the meter pipe diameter. Since the velocity "V" of the liquid disk is directed along the axis of the meter pipe, a voltage, signal "E_S", will be induced within this liquid which is mutually perpendicular to the direction of the liquid velocity and the flux linkages of the magnetic field; i.e., in the axial direction of the meter electrodes. This electrode voltage is the summation of all incremental voltages developed within each liquid particle that passes under the influence of the magnetic field.

This may be expressed mathematically as:

(Equation #1)

$$E_S = \frac{1}{\alpha} BDV$$

where:

E_s = induced electrode voltage
B = magnetic field strength
D = meter pipe diameter
α = dimensionless constant
V = liquid velocity

The metered liquid constitutes a continuous series of conductive liquid disks moving through a magnetic field. The more rapid the rate of liquid flow, the greater the instantaneous value of signal voltage as monitored at the meter electrodes.

4.1.2 Magnet Coil Drive Circuits

In older conventional Magnetic Flowmeters the integral magnet coils are driven directly by the customer's 50/60 Hz power service. Notably, however, the design of the Fischer & Porter Series 3000 Magnetic Flowmeter uses magnet drive circuits which are alternately energized bi-directionally at a low frequency rate as commanded by the associated Converter/Driver assembly. This provides maximum zero stability.

4.1.3 Volumetric Flow Rate Measurement

The Fischer & Porter Magnetic Flowmeter is a volumetric flow rate measuring instrument. This can be shown by substituting the physical equivalent of liquid velocity into equation #1 as follows:

(Equation #2)

$$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

Substituting for V in equation #1

$$E_S = \frac{1}{\alpha} BD \frac{4Q}{\pi D^2}$$

and solving for Q:

$$\therefore Q = \frac{\pi \alpha D}{4} \bullet \frac{E_s}{B}$$

Since $B = b\, E_r$

and since a, D and b are constant:

(Equation #3)

$$Q = \gamma \frac{E_s}{E_r}$$

where:

Q = volumetric flow rate
A = cross-sectional area
D = pipe section diameter
E_s = induced signal voltage
E_r = reference voltage
B = magnetic flux density
a = dimensionless constant
b & g = dimensional constant
V = liquid velocity

Therefore, volumetric flow rate is directly proportional to the ratio of the induced signal voltage to the reference voltage as measured by the Fischer & Porter Magnetic Flowmeter.

4.2 Operating Characteristics

4.2.1 Liquid Variables

4.2.1.1 Liquid Conductivity

The Series 3000 Magnetic Flowmeter requires a liquid conductivity of 5 microsiemens per centimeter or higher for operation. This minimum liquid conductivity requirement is not affected by the length of the signal interconnection cable when remote mounting of the Signal Converter is required, as long as the Fischer & Porter supplied or Fischer & Porter approved interconnection cable (with driven shields) is used. The nominal maximum transmission distance is limited to 30 meters (100 feet); however longer distances can be accommodated (contact Fischer & Porter for details). Thirty feet of cable is supplied as standard for remotely mounted Signal Converters.

4.2.1.2 Liquid Temperature

Having established the minimum liquid conductivity requirements for a given application, any liquid which exhibits equal or higher conductivity may be metered without concern for any system compensating adjustments. However, the effect of the liquid conductivity versus temperature should be considered since most liquids become less conductive at low temperatures.

Other normal effects of temperature, such as influence upon liquid viscosity and density, the size of the metering area, and the flux density of the magnetic field, have negligible or no effect upon metering accuracy.

4.2.1.3 Other Liquid Variables

Other liquid variables such as viscosity, density and liquid pressure have no direct influence on metering accuracy. Liquid density has no effect on volumetric flow rate since only the area of the meter pipe and liquid velocity are required to determine the rate of flow. Viscosity and metering pressure are restricted to physical limitations alone, such as the leakage pressure of the meter pipe flange connections.

4.2.2 Metering Characteristics

The metering pipe must be completely filled at all times for accurate results. Where there is a possibility of operation with a partially filled horizontal pipeline, it is recommended that the Magnetic Flowmeter be installed in a vertical section of that pipeline such that liquid flow moves upward. A vertical installation also offers the advantage of an even distribution of liner wear in the event that solid abrasives are being carried along in the liquid stream.

The magnetic flowmeter must be full at all times for accurate measurement.

The Fischer & Porter Magnetic Flowmeter will measure the total amount of material passing in the liquid stream. The meter will not, for instance, differentiate between the amount of liquid and the amount of entrained gases. Also, in the case of a slurry, it will not differentiate the amount of liquid from solids. If the liquid to mixant ratio is of importance to process control, then separate measurements of the concentration of the desired medium must be made and appropriate correction factors must be applied to the Magnetic Flowmeter output.

In applications involving variable quantities of uniformly dispersed, non-conductive mixing agents, it must be ascertained that the higher concentrations of mixant will not drive the average conductivity of the liquid mixture below the minimum conductivity level for the given installation.

5.0 CIRCUIT DESCRIPTION

Flowmeters of the pulsed DC type operate on the principle that unwanted electrode signals occur while the magnetic flux is changing. Accordingly, the signal converters have been designed to capture the electrode voltage only during that portion of the excitation cycle when the magnetic flux is constant. This interval occurs during the last 25% of each half excitation cycle. By using sampling techniques, the flow (differential mode) signal is measured only during the intervals that magnetic flux is constant.

$$\left(\frac{d\Phi}{dt} = 0\right)$$

Therefore, zero-instability due to changing flux is eliminated by use of the MAG-X design concept (sampling technique), providing a meter totally free of zero drift. Pulsed DC operation of a magmeter system eliminates those variables capable of causing drift of the meter zero point. A thorough discussion of Signal Converter operation is provided in the Instruction Bulletin supplied with the particular Signal Converter.

Models 10DX3111A & 10DX3111/3311G flanged flowmeter primaries contain two flux producing coils wired in series and a pair of diametrically opposed electrodes mounted at 90 degrees to the coil flux plane (refer to FIGURE 5-1 below). Meter coils are excited with approximately ±10 volts of pulsed DC. A precision current sensing network is connected in series with the coils. The current sense network produces what Fischer & Porter refers to as a "Reference Voltage", which is typically ±70 millivolts. The reference voltage is directly proportional to the strength of the magnetic field in the measuring tube and is measured by the signal converter. The reference voltage must be measured, since any variation in reference voltage will also produce a proportional change in electrode signal voltage, assuming an unchanged flow velocity. The current sense (reference network) may be in the Primary or the Secondary, depending on the model number and/or the design level.

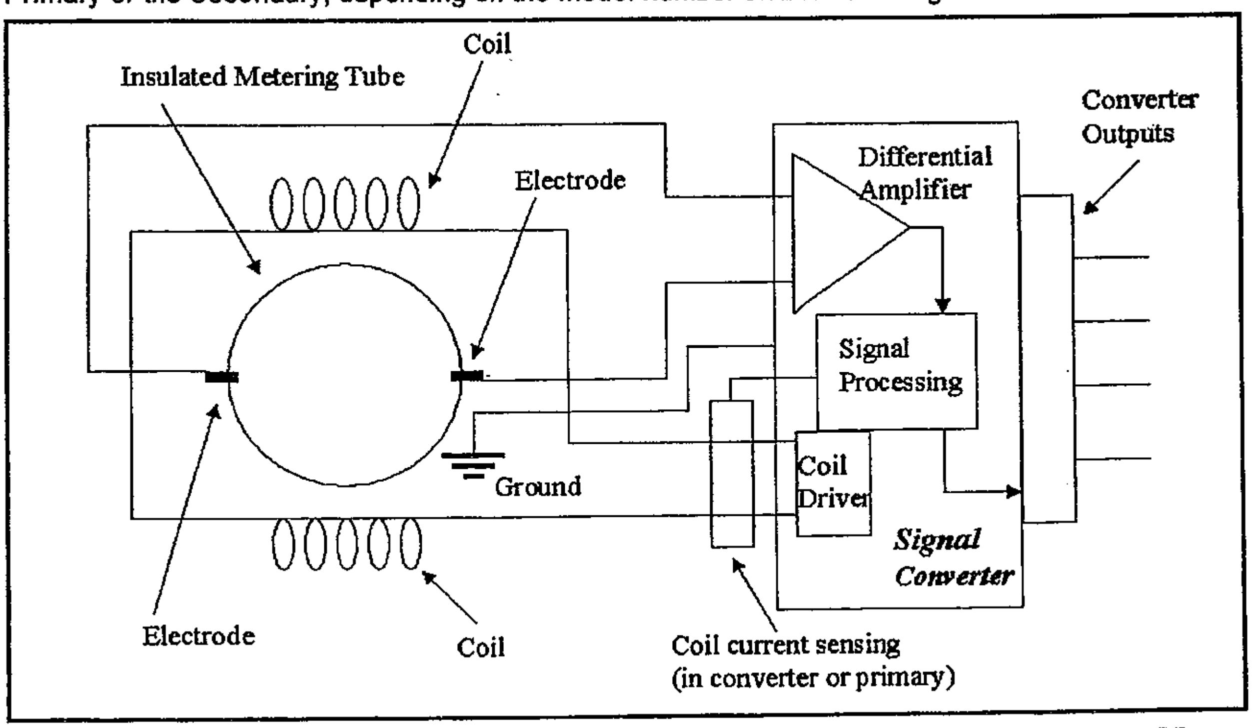


FIGURE 5-1. SIMPLIFIED MAGMETER SYSTEM BLOCK DIAGRAM

5.1 Remote Meters

5.1.1 Model 10DX3111A

In the remote meter configuration, all Flowmeter intraconnection wiring is terminated at the CMC/ZERO PC board located in the base of the meter housing.

The CMC PC Assembly provides several functions. These include:

1. Establishes interconnections between the Flowmeter internal wiring and the Signal Converter.
2. Permits factory adjustment of meter capacity values to a fixed value for each nominal size Flowmeter.
3. Permits factory adjustment of Flowmeter zero.
4. Establishes proper wiring connections for remotely mounted Signal Converters.

The Flowmeter provides two output signals to the associated Signal Converter:

- an electrode signal that contains the flow rate information
- a signal which is proportional to the magnet excitation current

Model 10DX3111A Primary provides a reference signal to the Converter, as discussed above. In Model 10DX3111G, this reference signal is produced in the remote Converter. The magnet coil drive circuitry is contained in the Signal Converter.

5.1.2 Model 10DX3111G

Primaries interfacing to remote M2 converters utilize the 686B804 primary connection board stacked underneath a 686B790 customer connection board. The 686B804 contains connection pads to bring electode and coil leads up to the customer area. Also, each electrode has an energy limiting barrier resistor in series with it as required for FM approval (refer to Figure 3-3). Thus a simplified cabling scheme between primary and secondary consists of a circuit common, a safety ground, two electrode leads, and two coil leads. The electrode area is often covered with an approved encapsulant.

5.2 Integral Meters

5.2.1 Model 10DX3311G

The model 10DX3311G flowmeter system is fitted with an integrally mounted M2 microprocessor Converter. A 686B776 pc assembly is installed underneath the converter module. This assembly incorporates the following functional blocks:

- A precision Kelvin current sensing network in series with the coils
- An encapsulated AC coupled buffer preamplifier for each measuring electrode
- An EEPROM for retention of Primary span and zero correction factors
- Input/output lines for 4-20 mA current, scaled pulse or data link, contact inputs/outputs (by jumper configuration; see table)

5.3 Terminal Numbering

THE FOLLOWING INFORMATION PROVIDES TERMINAL NUMBERING AND FUNCTION FOR THE INTEGRAL MODEL 10DX3311G CUSTOMER CONNECTION TERMINALS (Refer to Figure 3-5)

TERMINAL BLOCK

39	40	-	+	V2	V1	V3	V4	L		N

TERMINALS	TERMINAL FUNCTION
39/40	a) Zero return or totalizer reset (software selectable) b) Solid-state status contact (39 = emitter) c) Forward flow scaled pulse output, open collector (39 = emitter)
-/+	4-20 mA current output
V2/V1	a) Forward scaled pulse output (V1 = negative) b) Data link transmit (V1 = negative)
V3/V4	a) Reverse scaled pulse output (V3 = negative) b) Data link receive (V3 = negative)
L/N	Signal converter power supply (N is negative or neutral)

6.0 MAINTENANCE

6.1 General

Except for an occasional performance verification check, there is no required routine maintenance for the Series 3000 Magnetic Flowmeter. For practical reasons it is suggested that the meter body not be disassembled. If disassembled, complete waterproof sealing is required for satisfactory operation and is best done at the factory. Replacement of faulty magnet drive coils and electrode replacement is a factory operation. Factory calibration after this type of repair is the only way to guarantee meter accuracy.

Fischer & Porter offers a Repair/Exchange Program to facilitate replacement of a defective meter or Converter. If the equipment is beyond the warranty limit, under this program a fixed price will be charged for replacement of defective equipment, with appropriate credit issued when the repairable unit is received by Fischer & Porter (charges prepaid). The equipment available under this program is as follows:

- the complete meter with integrally mounted Signal Converter
- the meter and associated primary board; that is, the hydraulic portion without the Signal Converter
- the Signal Converter

WARNING
All Flowmeters and/or Signal Converters being returned to Fischer & Porter for repair must be free of any hazardous materials (acids, alkalis, solvents, etc.). A Material Safety Data Sheet (MSDS) for all process liquids must accompany returned equipment. Contact Fischer & Porter for authorization prior to returning equipment.

NOTE
Operation and maintenance procedures for the Signal Converter are provided in the Instruction Bulletin supplied with the Signal Converter.

When communicating with Fischer & Porter in regard to replacement of a complete meter (with integrally mounted Converter), the meter body, or the Signal Converter, it is important to refer to the complete instrument serial number to assure that the correct replacement will be supplied. This information is provided on the manufacturing specification sheet supplied with the Magnetic Flowmeter, and on the instrument data tag.

CAUTION
Some of the IC devices used in the signal converter are static sensitive and may be damaged by improper handling. When adjusting or servicing the signal converter, use of a grounded wrist strap is recommended to prevent inadvertant damage to the integral solid state circuitry.

6.2 System Troubleshooting

In the event that faulty operation of the Magnetic Flowmeter is evident, the following procedure can be used as a guide to isolate the malfunctioning device to either the primary meter or the Signal Converter. A standard multimeter and an oscilloscope are suitable for making most of the test measurements.

To supplement the following discussion refer to:

Section 5.0 Circuit Description

Signal Converter ... refer to applicable Instruction Bulletin

NOTE
The Series 3000 Magnetic Flowmeter housing is supplied as a sealed unit. Therefore, customer field repairs to these meters are not recommended. In the event of a malfunction, repairs should only be performed by an Fischer & Porter field service engineer, or the complete meter returned (shipping charges prepaid) to Fischer & Porter for service.

WARNING
ELECTRICAL SHOCK HAZARD. Equipment powered by an AC line voltage presents a potential electric shock hazard. Servicing of the Magnetic Flowmeter or Signal Converter should only be attempted by a qualified electronics technician.

1. If improper meter operation is suspected, proceed as follows:

   a) Remove access covers from the junction box and the Converter housing (remote or integral).

   b) Inspect for evidence of water entry in the junction box and Converter housing.

If water is present in either the junction box or converter housing of the flowmeter, immediately de-energize system power to eliminate the possibility of a shock hazard.

The presence of water in either the converter housing or the terminal box atop the remote primary most often results in irreparable damage to the circuit board assemblies inside. If such damage is evident, the meter should be removed from the process pipeline and returned to Fischer & Porter for repair. It is also important that the source of the water-entry be found so that the situation doesn't reoccur when the meter is placed back into service.

Should water be found inside the wiring compartment of an integrally mounted converter housing, the circuit board assembly in this section may be replaced in the field (Consult the factory for additional instructions if this procedure becomes necessary).

the body should exceed 20 MΩ. If the measured resistance is within specifications, reconnect the wires to the terminal block.

If readings in this section are not within specification, the Signal Converter may display a **"U-ref too low"** error message.

6.3.1.3 Model 10DX3311G

There are two magnet coils in the meter that are wired in series and brought up to terminals M1 & CT and MR & CT1 of the flowmeter PC board in the electronics base.

Verify that the system power service has been de-energized. Loosen and remove the four screws that hold the Signal Converter to the base. Disconnect the connector from signal (P1) on the CMC PC board and the power (P3) connector to the Converter (refer to Figure 3-2) and set the Converter module aside. Measure the series resistance of the magnet coils by connecting the ohmmeter between terminals M1 & MR. The value displayed should be between 10Ω and 80Ω.

If it is suspected that process fluid or excess moisture has entered the Primary housing, unsolder the coil wires from the M1 and MR pads. Verify that the resistance of each coil lead (M1, MR and CT) to the flowmeter body is greater than 20 MΩ or infinite. If the resistance value is incorrect, the coils are defective and the meter must be returned to the factory for service.

6.3.2 Electrode Check

The electrode check is essentially a resistance measurement that can be made to establish that a short (or high resistance leakage path) does not exist between one, or both, electrodes and the meter body. Verify that the system power service has been de-energized.

To thoroughly test the electrodes of flowmeters with remote converters (Models 10DX3111A & 10DX3111G), meters must be tested under both full and empty pipe conditions. If this is not possible, it may still be helpful to perform one of the tests since useful partial information may be gained from the results of either portion of the test.

6.3.2.1 Full Pipe Test

The wetted electrodes of all flowmeters manufactured in accordance with FM Div.1 or Div.2 requirements must have energy-limiting resistance placed in series with them. Depending on the model being tested, the nominal resistance value is 100,000 ohms and will add to any resistance measured between the wetted electrode and the fluid in contact with that electrode.

Electrode full pipe measurements should be made with the ohmmeter placed on its highest range. An AC type ohmmeter (i. e. conductivity bridge) is preferred because DC voltage will tend to polarize the electrode (but will nevertheless provide meaningful information). Connect the ohmmeter positive lead first to electrode terminal "1" and then to electrode terminal "2" with the negative lead to terminal "3" or the flowmeter body. The measured resistance should be 100,000 ohms plus the intrinsic resistance between electrode and fluid (typically 50,000 additional ohms or less). If using a DC ohmmeter, the resistance between the electrode and the fluid will tend to increase as the electrode becomes polarized by a DC signal. This effect is normal. AC resistance readings will not vary once established. Readings greater than 150,000 ohms may indicate a coated electrode. Infinite readings indicate a broken connection in the electrode wiring path. Meters with infinite full pipe readings should be returned to the factory for repair.

6.3.2.2 Empty Pipe Test

If possible, the pipeline should now be drained and the flowmeter should be given a few minutes to allow the fluid to drain off the electrode to liner interface. Connection of either a DC or AC ohmmeter between electrode terminals "1" or "2" and the meter body (terminal "3") should result in a reading greater than 20 MΩ. Lower readings indicate either that process fluid has leaked behind the electrode or that moisture has entered the flowmeter housing. If this is the case, the defective meter should be returned to the factory for repair.

6.3.2.3 Electrode Voltage Test

This test may only be performed on remote models (10DX3111A & 10DX3111G). If no erroneous readings are found when the electrode resistance test is performed, an additional test may be performed with the system powered and the field wiring restored. Use a digital voltmeter, with a range-setting of 20VDC, to measure the voltage between electrode terminals 1 & 3 (common) and between electrode terminals 2 & 3. The voltage readings should be between ±10 mV and ±2 VDC and should not differ by more than 0.4 VDC. If measured voltages are outside of these ranges, it may indicate that an electrode is open, shorted or that the process fluid is non-conductive.

NOTE

Model 10DX3311 flowmeters with integrally mounted signal Converters incorporate a buffer preamplifier for each electrode. Since this preamplifier is also encapsulated, an on-site evaluation of the condition of the electrodes is not possible.

If the results of the procedures in Sections 6.3.2.1 through 6.3.2.3 indicate normal meter parameters, the flowmeter may be returned to service.

Refer to the instruction bulletin supplied with the Signal Converter for additional advice on troubleshooting flowmeter electronics

7.0 PARTS LIST

TABLE 7-1. FLANGE GASKETS FOR METER BODY

> NOTE
> Polyurethane, neoprene & hard-rubber lined meters use neoprene gaskets. TEFLON & TEFZEL lined meters use TEFLON gaskets.

Two gaskets are required for each meter. If the meter has grounding rings, two additional gaskets are required for each meter.

Meter Size		Flange Class	Liner Material			
Inches	mm		TEFLON / TEFZEL	Polyurethane	Neoprene	Hard-Rubber
6	150	ANSI 150	333N811P30	333N811Q10	333C371Q10	
		ANSI 300	333N801P30	333N801Q10	333C378Q10	
8	200	ANSI 150	333N812P30	333N812Q10	333C372Q10	
		ANSI 300	333N802P30	333N802Q10	333C379Q10	
10	250	ANSI 150	333N807P30	333N807Q10	333C382Q10	
		ANSI 300	333N821P30	333N821Q10	333C514Q10	
12	300	ANSI 150				
		ANSI 300				

TABLE 7-2. LINER PROTECTOR/GROUNDING RINGS FOR TEFLON & TEFZEL LINED METERS

Order number consists of two protector plates and mounting screws. Grounding rings are not available for this application. When ordering, specify **614B384U__** and suffix from the table below.

Protector Plate Material	Meter Size Inches = (mm) =	Flange Rating ANSI Class 150				Flange Rating ANSI Class 300			
		6 (150)	8 (200)	10 (250)	12 (300)	6 (150)	8 (200)	10 (250)	12 (300)
316 sst	Suffix =	01	07	13	19	04	10	16	22
HAST "C"	Suffix =	02	08	14	20	05	11	17	23

TABLE 7-3. GROUNDING RINGS

> NOTE
> Polyurethane, neoprene & hard-rubber lined meters use neoprene gaskets. TEFLON & TEFZEL lined meters use TEFLON gaskets.

Order number consists of one grounding ring and mounting screws. Order a quantity of two for each meter. Order by the referenced part number.

Meter size		Flange Rating ANSI Class 150	Flange Rating ANSI Class 300
		304 sst with neoprene gasket	304 sst with neoprene gasket
Inches	mm	Part Number	Part Number
6	150	644B009U01	644B009U23
8	200	644B009U03	644B009U25
10	250	644B009U69	644B009U71
12	300	644B009U70	644B009U72

Meter size		Flange Rating ANSI Class 150	Flange Rating ANSI Class 300
		304 sst with TEFLON gasket	304 sst with TEFLON gasket
Inches	mm	Part Number	Part Number
6	150	644B009U02	644B009U24
8	200	644B009U04	644B009U26
10	250	644B021U19	644B021U21
12	300	644B021U20	644B021U22

TABLE 7-4. CONVERTER BASE AND JUNCTION BOX GASKETS

Integrally mounted Converter	
Converter Base Gasket	D101A009U01
Junction Box Gasket	D333F004U01

Remotely mounted Converter	
Meter Junction Box Cover Gasket	101A820U01

CUT ALONG LINE, FOLD, STAPLE

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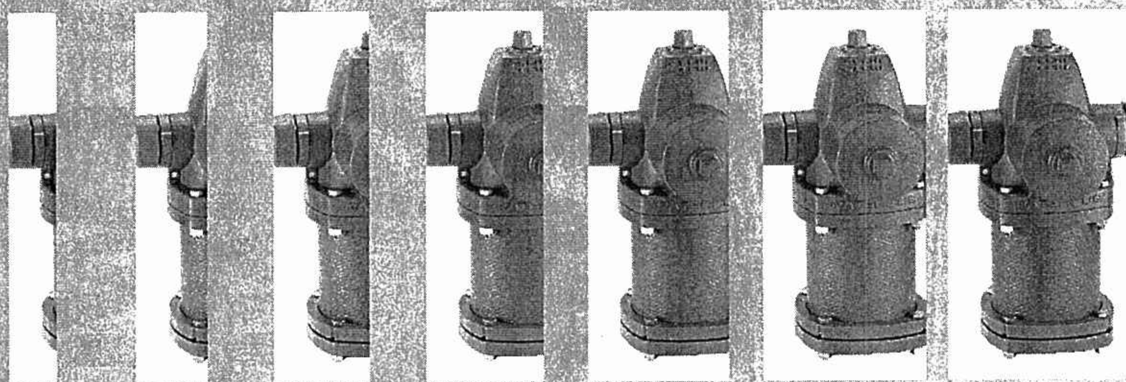
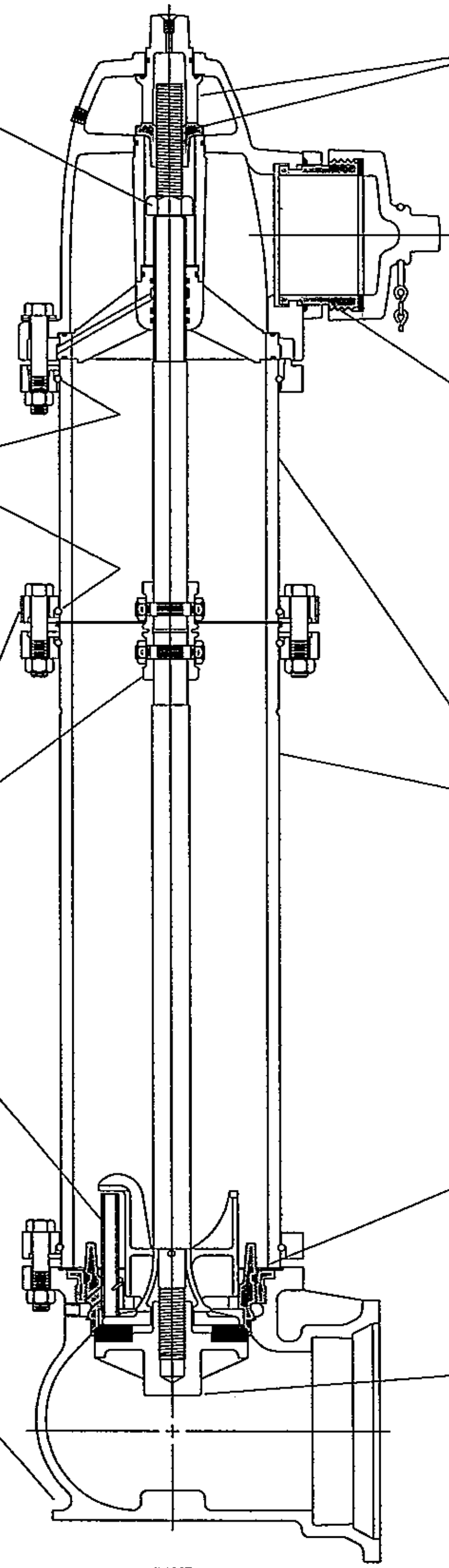
AMERICAN FLOW CONTROL



DUCTILE IRON 250 P.S.I.

WATEROUS 5 1/4" PACER FIRE



TRAVEL STOP NUT-Provides a positive limit to main rod travel.

360° NOZZLE SECTION ROTATION-The Waterous stainless steel retaining ring system allows 360° rotation by merely loosening the flange bolts, and turning the nozzle section to the exact position desired.

TRAFFIC SECTION-Parts are designed to break at the ground line. Simple low cost repair kit available.

ALL BRONZE DRAIN-No composition, plastic, rubber or leather face to wear, peel or crack.

FLAT BOTTOM AND STRAPPING LUGS-All standard to make solid, straight installation faster and easier.

TWO PIECE OPERATING NUT-Ductile iron upper section provides strength for wrenching. Lower portion is bronze for smooth operation and corrosion resistance.

MECHANICALLY ATTACHED NOZZLES-Field replacement of damaged nozzles in minutes by one person.

CENTRIFUGALLY CAST DUCTILE IRON BARRELS-Stronger, smoother and more uniform than static cast barrels.

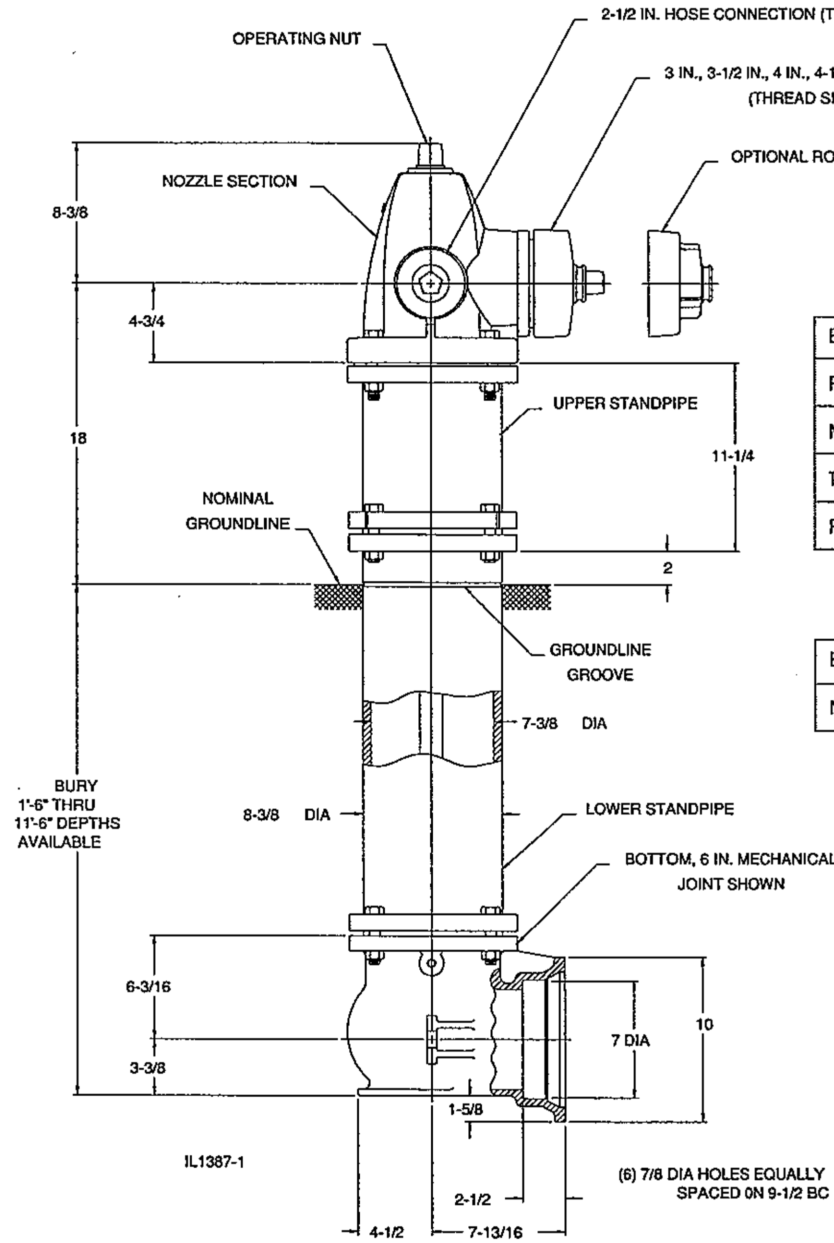
BRONZE TO BRONZE SEATING-O-ring protected bronze valve seat threads into a bronze insert in the hydrant bottom.

INTEGRAL CAP NUT AND LOWER WASHER-Protects rod threads from corrosion and makes servicing easy. Valve assembly locked in place. It cannot detach accidentally.

Fully complies with AWWA C-502 and is available in configurations which are UL Listed and FM Approved.

 AMERICAN FLOW CONTROL

5-1/4" PACER FIRE HYDRANT

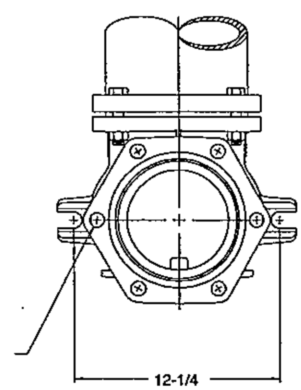


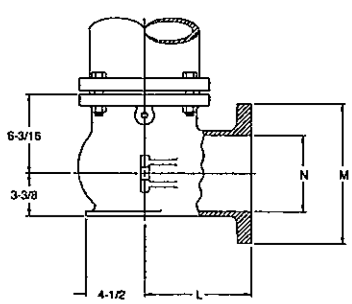
6" BOTTOM

End Connection	L	M	N
Flanged	8-1/4	11	6
Mechanical Joint	7-13/16	10	7-1/32
Tyton	9-1/16	8-21/32	7-1/32
PVC	9-11/16	8-9/32	6-3/4

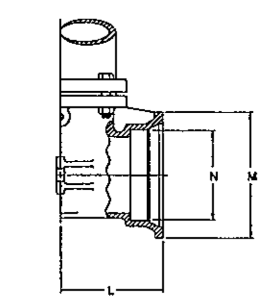
8" BOTTOM

End Connection	L	M	N
Mechanical Joint	9-5/8	12	9-3/16

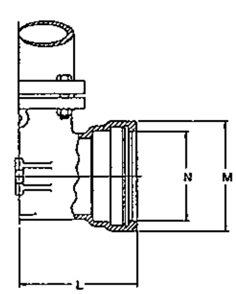




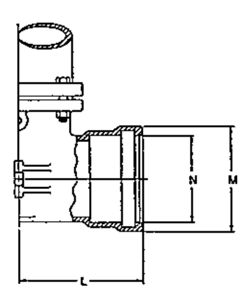
FLANGED CONNECTION



MECHANICAL JOINT CONNECTION

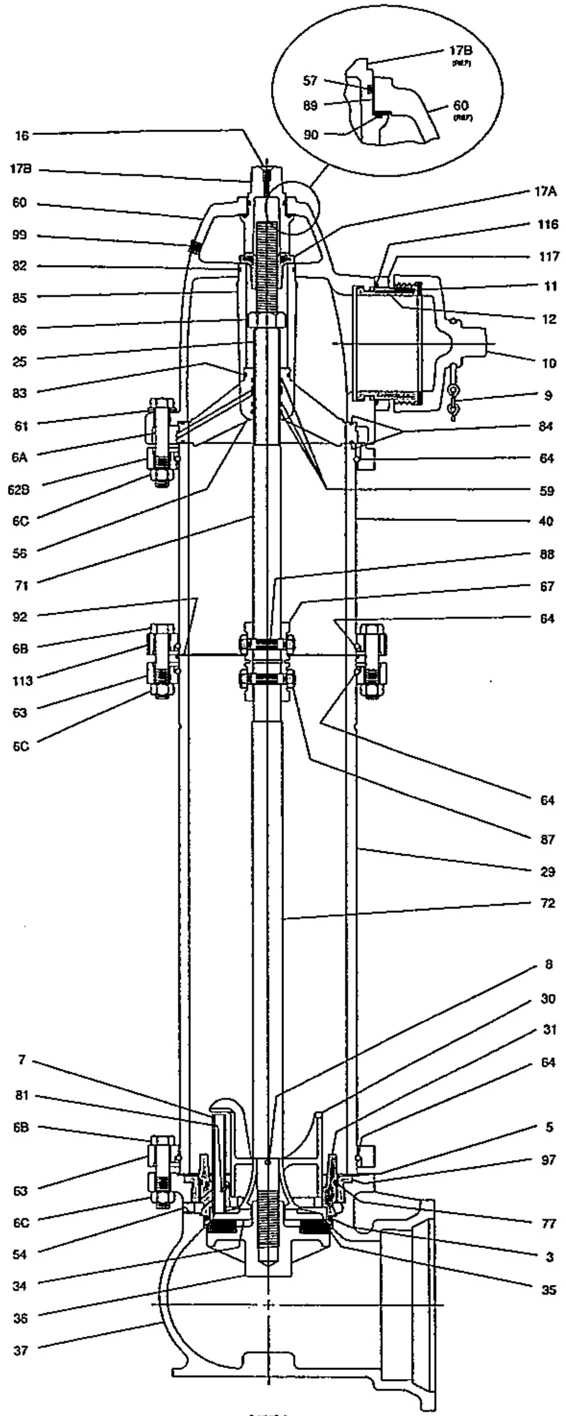


TYTON JOINT CONNECTION



PVC JOINT CONNECTION

5-1/4" PACER FIRE HYDRANT



REF NO.	DESCRIPTION	MATERIAL
3	O-ring (Lower valve seat), 5-5/8 x 5-7/8	Buna N
5	Lower standpipe gasket	Neoprene
6A	Hex hd bolt, 5/8-11 x 3-3/4 in.	Zinc plated steel
6B	Hex hd bolt, 5/8-11 x 3 in.	Zinc plated steel
6C	Hex nut, 5/8-11	Zinc plated steel
7	Drain plunger	Red brass
8	Cotter pin, 1/4 x 1-1/2 in.	Stainless steel
9A, 9B	Nozzle cap chain, single or double	Zinc-plated steel
10	Nozzle cap, hose or pumper	Ductile iron
11	Cap gasket, hose or pumper	Neoprene
12	Nozzle, hose or pumper	Brass
16	Flat hd screw, 1/4-20 x 1/2 in.	Stainless steel
17	Operating nut (one-piece)	Bronze
17A	Lower operating nut	Bronze
17B	Upper operating nut	Ductile iron
25	Valve rod bushing (included with 71 & 28)	Red brass
28	Rod Assembly (includes 25) (non-Traffic model)	Steel rod
29	Lower standpipe (Traffic model)	Centrifugally cast ductile iron pipe
29	Standpipe (non-Traffic model)	Centrifugally cast ductile iron pipe
30	Crossarm	Bronze
31	Valve seat	Bronze
34	Upper valve washer	Ductile iron
35	Main valve rubber	Urethane
36	Lower valve washer	Ductile iron
37	Hydrant bottom	Ductile iron
40	Upper standpipe (Traffic model)	Centrifugally cast ductile iron pipe
54	Drain bushing	Brass
56	Support wheel	Ductile iron
57	O-ring (Operating nut), 1-1/2 x 1-3/4	Buna N
59	O-ring (Support wheel), 1-1/8 x 1-3/8	Buna N
60	Nozzle section	Ductile iron
61	Bury depth plate	Aluminum
61	Bury depth plate washer	Zinc plated steel
62B	Upper standpipe flange	Ductile iron
63	Standpipe flange	Ductile iron
64	Flange lock ring	Stainless steel
67	Coupling sleeve (2 halves)	Cast iron
71	Upper rod assembly (includes 25) (Traffic model)	Steel rod
72	Lower rod (Traffic model)	Steel rod
77	O-ring (Upper valve seat), 5-7/8 x 6-1/8	Buna N
81	Groove pin, 3/32 x 7/16 in.	Beryllium copper
82	O-ring (Upper tube seal), 2-3/8 x 2-5/8	Buna N
83	O-ring (Lower tube seal), 1-7/8 x 2-1/8	Buna N
84	Support wheel gasket	Buna N
85	Support tube	Ductile iron
86	Stop nut, 1"- 8	Zinc plated steel
87	Coupling nut, 1/2-20	Brass
88	Coupling stud, 1/2-20 x 2-9/16 in.	Stainless steel
89	Nozzle section bushing	Brass
90	Thrust ring	Teflon
92	Upper standpipe gasket	Neoprene
97	Valve seat insert	Bronze
99	Pipe plug, 1/4 NPT	Brass
101	Weathershield nut	Ductile iron
102	Groove pin, 1/4 x 2 in.	Stainless steel
113	Breakable flange	Ductile iron
116	O-ring (pumper nozzle), 5-1/4 x 5-3/4	Buna N
117	Pumper nozzle retainer	Ductile iron
118	O-ring (hose nozzle), 3-1/4 x 3-5/8	Buna N
119	Hoze nozzle retainer	Ductile iron

NOTES

1. 250 p.s.i.g. rated working pressure.
2. Meets or exceeds all requirements of AWWA C-502.
3. May be ordered in configurations which are UL Listed and FM approved.
4. Nominal turns to open is 18.

SUBMITTAL DATA

Depth of trench or bury	Number of hose nozzles			Steamer nozzle size		
Inlet pipe connection size	Hose nozzle size			Nozzle cap chains	Yes	No
Type of base connection	Direction to open			City Specification		
Paint color	Steamer nozzle	Yes	No			

FEATURES

The **Waterous Pacer's** sleek and stylish design blends perfectly with today's modern architecture. The **Pacer** is rated for 250 p.s.i.g. and exceeds all of the requirements of AWWA C-502. Ductile iron construction assures strength and durability. Introduced in 1967, the **Pacer** fire hydrant provides real solutions to today's system demands. With many cities experiencing increased pressure to stretch their dollars it is important to note that the **Pacer** hydrant can be maintained by just one person. The removal of four nuts and bolts allows access to all working parts. The **Pacer** hydrant is loaded with all of the features expected from a high quality fire hydrant. The all bronze seat and bronze seat insert assure that the **Pacer** hydrant remains easy to repair. The **Pacer** has been manufactured for more than 30 years while still maintaining complete parts interchangeability.

The **Pacer hydrant** has these standard features:

- **All bronze drain**
- **Travel stop nut located in top of hydrant**
- **Easy 360° rotation of nozzle section**
- **250 p.s.i.g. working pressure rating**
- **Shell tested at 500 p.s.i.g.**
- **Sealed lubrication chamber**
- **Over 30 years of continuous parts interchangeability**
- **Ductile iron nozzle section, upper & lower stand pipes & hydrant base**
- **Bronze-to-bronze seating**
- **Bronze cross arm**

BENEFITS

Easy Nozzle Section Rotation

The **Pacer's** exclusive stainless steel flange lock ring allows 360 degree rotation of nozzle section by merely loosening four bolts and turning nozzle section to the exact position required. This is done without damage to barrel gaskets.

Sealed Lubrication Chamber

O-rings seal the operating threads from moisture and retain lubricant which greatly reduces routine maintenance.

All Bronze Drain

No composition rubber, plastic or leather to wear, chip or crack. Virtually no leaks, nor adjustments are ever required. Bronze sliding drain valve is free to center itself so it always closes tightly, even if a foreign object gets into the barrel.

Top Travel Stop Nut

Helps prevent stem buckling and damage to bronze components.

SPECIFICATIONS

Fire hydrants shall meet or exceed AWWA C502, latest revision. Rated working pressure shall be 250 p.s.i.g., test pressure shall be 500 p.s.i.g., and hydrants shall include the following specific design criteria:

The nozzle section, upper and lower stand pipes and hydrant base shall be ductile iron.

The main valve closure shall be of the compression type, opening against the pressure and closing with the pressure. Nozzle section to be designed for easy 360 degree rotation by the loosening of no more than four bolts.

The seat diameter shall be 5-1/4". Hydrant must be designed so that removal of all working parts can be accomplished without excavating. The bronze seat shall be threaded into mating threads of bronze for easy field repair.

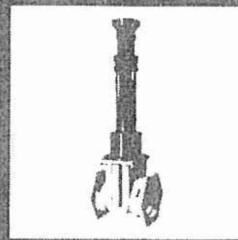
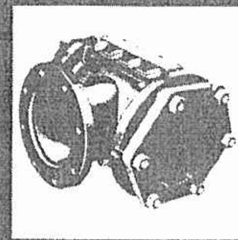
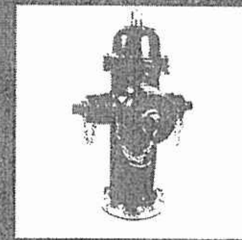
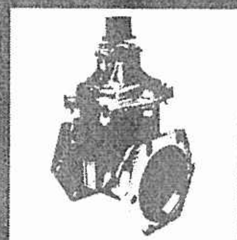
The draining system of the hydrant shall be bronze and be positively activated by the main operating rod. Hydrant to be furnished with a sliding bronze drain valve. Sliding drain valves made of rubber, plastic or leather will not be allowed.

Hydrant must have an internal travel stop nut located in the top housing of the hydrant.

Hydrant operating threads to be factory lubricated, and be O-ring sealed from water, moisture and foreign matter.

Hydrant must have a traffic flange design allowing for quick and economical repair of damage resulting from a vehicle's impact.

Hydrants shall be **Waterous Pacer.** (Model number WB-67-250).


American Flow Control®

American-Darling Valve and Waterous

A Division of American Cast Iron Pipe Company

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American-Darling Valve
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Phone: 1-800-326-7082
Fax: 1-800-610-3569
e-mail: bpatton@acipco.com

Waterous Company
125 Hardman Avenue South
South St. Paul, MN 55075-1191
Phone: 1-888-245-9443
Fax: 1-800-601-2809
e-mail: kmmastel@waterousco.com

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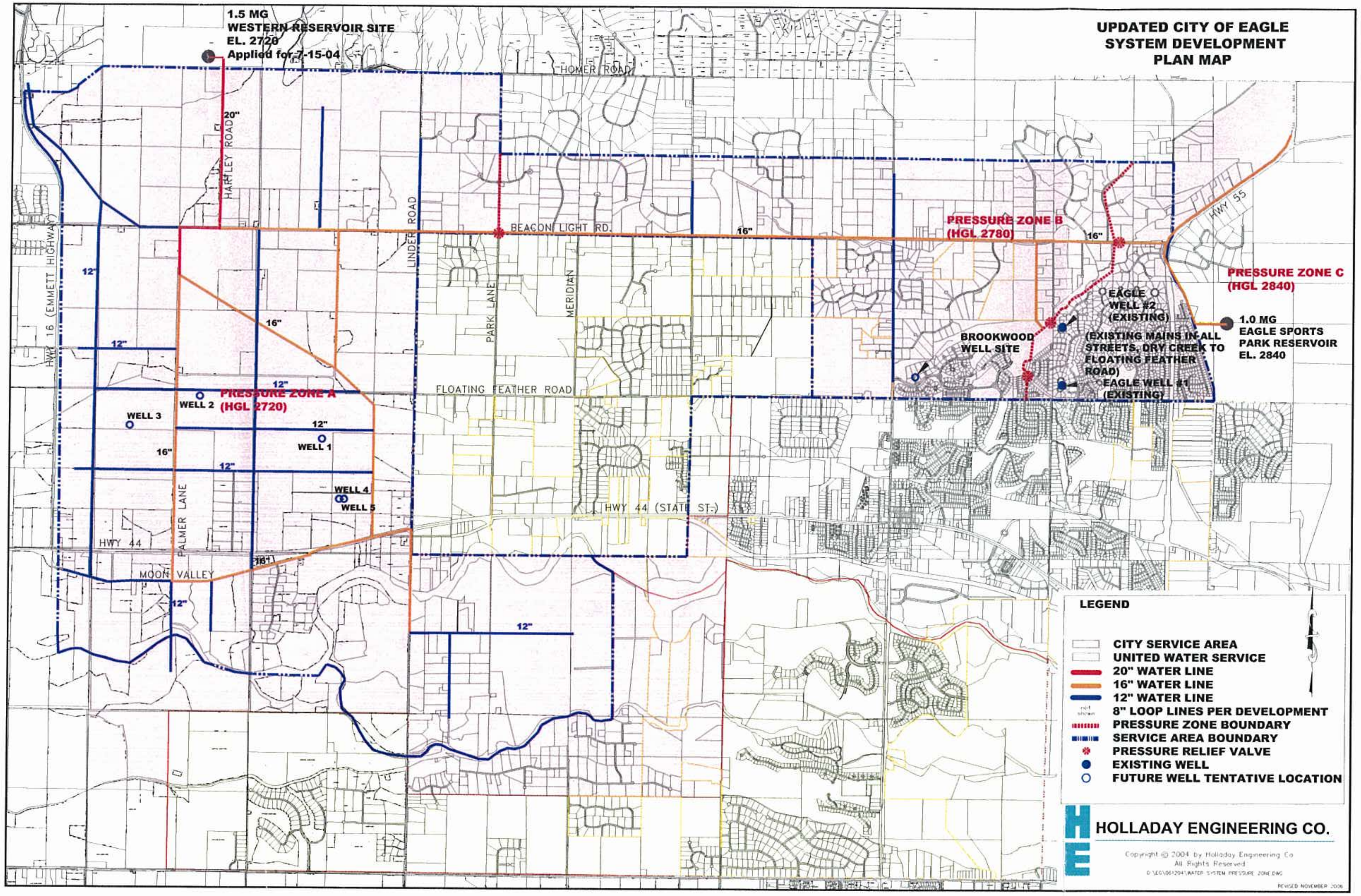
EXHIBIT 6



Eagle Exhibit 6


UPDATED CITY OF EAGLE
SYSTEM DEVELOPMENT
PLAN MAP
1.5 MG
WESTERN RESERVOIR SITE
EL. 2720
Applied for 7-15-04
HOMER ROAD
HARTLEY ROAD
LINDER ROAD
BEACON LIGHT RD.
PARK LANE
MERIDIAN
FLOATING FEATHER ROAD
HWY 44 (STATE ST.)
HWY 44
MOON VALLEY
PALMER LANE
HWY 16 (EMMETT HIGHWAY)
HWY 55
PRESSURE ZONE A
(HGL 2720)
PRESSURE ZONE B
(HGL 2780)
PRESSURE ZONE C
(HGL 2840)
WELL 1
WELL 2
WELL 3
WELL 4
WELL 5
BROOKWOOD
WELL SITE
EAGLE
WELL #2
(EXISTING)
(EXISTING MAINS IN ALL STREETS, DRY CREEK TO FLOATING FEATHER ROAD)
EAGLE WELL #1
(EXISTING)
1.0 MG
EAGLE SPORTS
PARK RESERVOIR
EL. 2840
20"
16"
12"
LEGEND
CITY SERVICE AREA
UNITED WATER SERVICE
20" WATER LINE
16" WATER LINE
12" WATER LINE
not shown
8" LOOP LINES PER DEVELOPMENT
PRESSURE ZONE BOUNDARY
SERVICE AREA BOUNDARY
PRESSURE RELIEF VALVE
EXISTING WELL
FUTURE WELL TENTATIVE LOCATION
HOLLADAY ENGINEERING CO.
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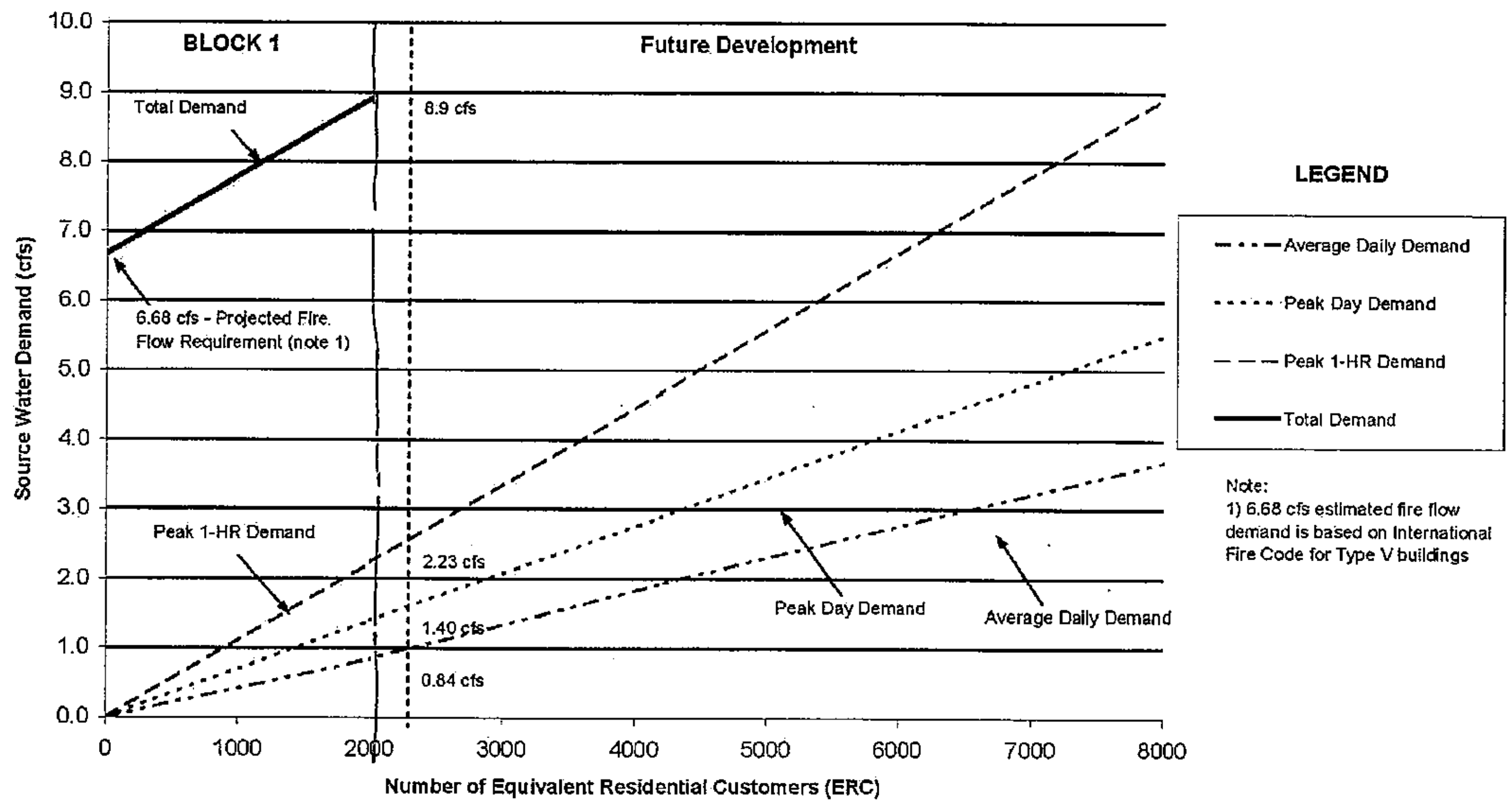
G:\EG\061204\WATER SYSTEM PRESSURE ZONE.DWG
REVISED NOVEMBER 2006

Exhibit 6

Eagle Exhibit 7

Projected Water Demands For Western Expansion Area
City of Eagle Amended Water System Master Plan



HOLLADAY ENGINEERING CO.

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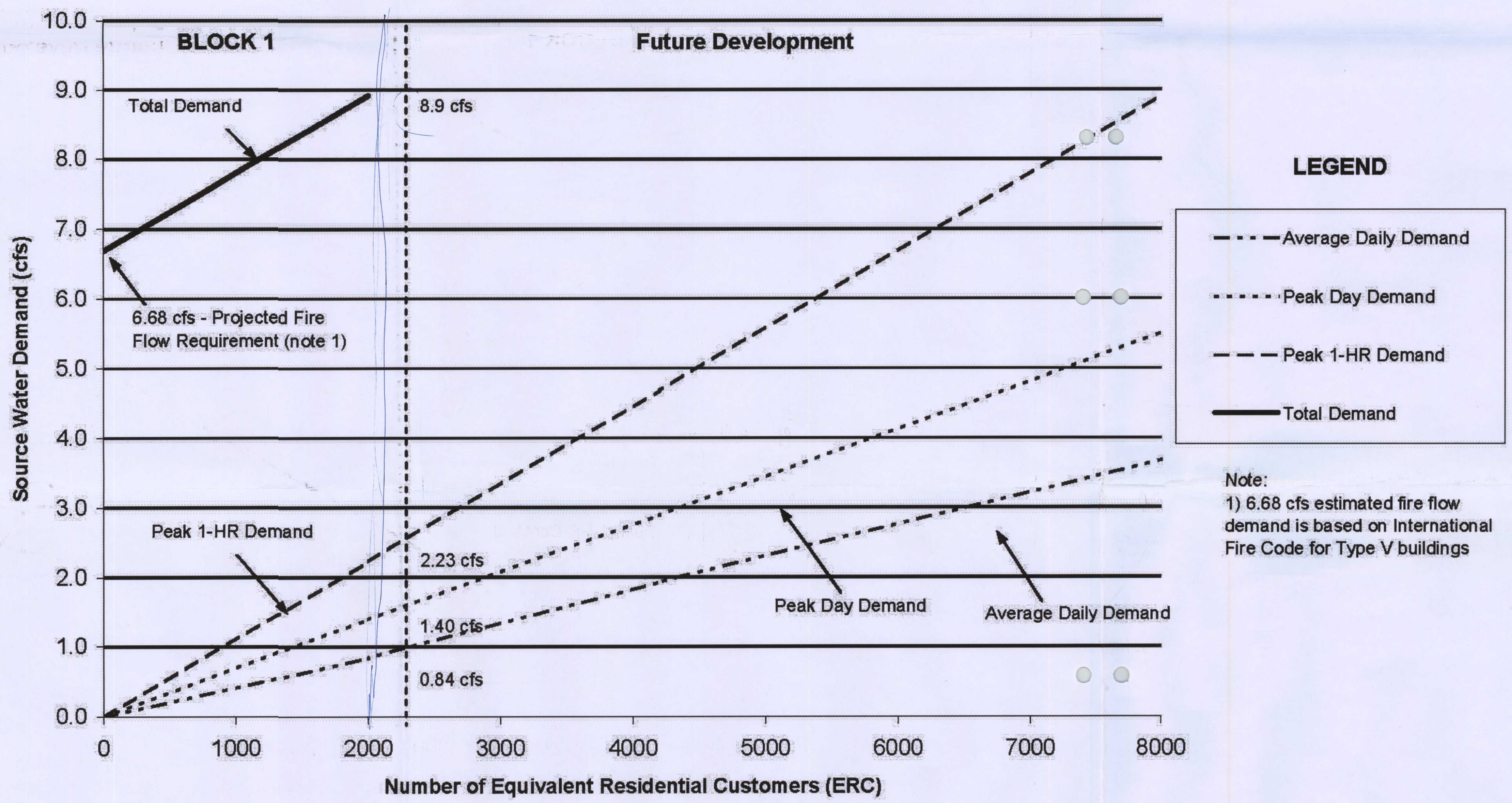
Projected Water Demands For Western Expansion Area
City of Eagle Amended Water System Master Plan



Note:
1) 6.68 cfs estimated fire flow demand is based on International Fire Code for Type V buildings

HOLLADAY ENGINEERING CO.

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Exhibit 7

Summary of Potential Well Interference

Protestant	Potential Drawdown (4.7 cfs for 365 days).
Cheney, Tim	unknown
City of Star	0.63 ft.
Combe, Dean	0.88 ft.
Dixon, Mike	well 1 : 3.97 ft. - 7.95 ft. well 2: 0.92 ft. well 3: 0.90 ft.
Flack, Bill	well 1 : 0.80 ft. well 2: 6.65 ft. well 3: 0.80 ft. well 4: 0.80 ft. well 5: 3.21 ft.- 6.43 ft.
Hanson, Bob	0.73 ft.
Heath, Michael	1 .06 ft.
Howarth, C. H.	~~1.06 ft.~~ 12.41
Hutton, Terry	2.60 ft. - 6.43 ft.
Mares, Norma	0.37 ft.
McCollum, Michael	unknown
Meissner, Charles	well 1 : 0.96 ft. well 2: 0.96 ft. well 3: 0.96 ft.
Mellies, leeRoy	4.15 ft. - 8.31 ft.
Moyle, Joseph	well 1 : 6.91 ft. well 2: 7.73 ft.
Muller, Eugene	9.58 ft.
Purdy, Dana & Vicki	well 1: 10.25 ft. well 2: 4.74 ft. - 9.47 ft.
Reeser, Scott	1 .30 ft.
Rosti, Sam	9.42 ft.
Roundtree, Bud	1 .11 ft.
Schreiner, Ronald	well 1 : 3.63 ft. - 7.26 ft. well 2: 3.36 ft. - 7.26 ft.
Taylor, Mary	0.87 ft.
United Water Idaho	Redwood Ck. well 1 : 6.28 ft. Redwood Ck. well 2: 5.84 ft. Floating Feather well: 7.66 ft. Fox Tail well: 4.68 ft. Spurwing well: 5.50 ft.
Wilder, Ralph	1 .17 ft.

Eagle Exhibit 8