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SPECIFICATION FOR LHC MTF FEEDBOX (STAND 4) AT FERMILAB
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1.0 Scope

This specification defines the requirements for a Magnet Test Feedbox including a vacuum-insulated low-temperature pressure vessel to be delivered to Fermilab for use at the Magnet Test Facility.

2.0 General feedbox description (see page 7 of specification for 3-D image)

2.1 This magnet test feedbox will be a vacuum-jacketed assembly for connecting power, instrumentation, and cryogens to a 1.9 Kelvin superconducting magnet. The interface to the cryogenic system will include bayonet-style connections and welded connections. Connections to the magnet cryostat will be flanged. (Those flanges are not part of the present procurement.) The feedbox will include an ASME code-stamped helium vessel which is part of a "double-bath" system, with 4.4 K liquid helium above a barrier, called the "lambda plate", and 1.9 K, 1 atmosphere helium below the lambda plate and extending through pipes into the superconducting magnet on the test bench. The helium vessel and associated piping will be installed in a vacuum-insulated container by the vendor. Pressure relief devices as required by the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 will be provided and installed by Fermilab.

3.0 Fermilab design responsibilities

3.1 Fermilab provides the flow schematic, ME-304900, as a “map” of the system.
3.2 Fermilab provides design details for all aspects of the feedbox assembly except items listed in paragraph 4.0 below.
3.3 Fermilab drawings are numbers 1670-M_-304850 through 1670-M_-304903, listed at the end of this specification.
3.4 The assembly drawings of this system are Vacuum Vessel Assembly #1670-MD-304870, Helium Vessel Assembly #1670-ME-304850 and associated drawings, and Flow Schematic #1670-ME-304900.
3.5 The vendor may suggest alternate design details, but Fermilab must approve these in writing before they are incorporated into the design.

4.0 Vendor design responsibilities. It is Fermilab's intent that the manufacturer of this dewar shall be a firm regularly engaged in the design and manufacture of cryogenic equipment for liquid helium. Some design details are left up to the vendor.

4.1 The vendor has responsibility for the design details of the inner vessel stiffening rings (if any), weld preps and welds, and any other inner vessel code issues. Dimensions shown on Fermilab drawings are to be maintained unless a violation of the ASME code would result. Material is a non-magnetic weldable 300-series stainless steel unless otherwise noted. Material thickness and weld design and dimensions, where not specified by Fermilab, must be determined or verified by the manufacturer to ensure compliance with pressure vessel code requirements. Fermilab must approve any change in dimensions from those on Fermilab drawings in writing before being implemented.

4.2 The internal pipe locations, 80 K shield details, and vacuum break details may be modified to the vendor's preference with written approval of Fermilab.

4.3 The vendor, subject to Fermilab approval may select the type of multilayer insulation.

4.4 Valve selection is the responsibility of the vendor. Fermilab reserves the right to review and approve the valves which are selected. See also paragraph 8.0 for the valve specifications.

4.5 Shipping restraints for the inner vessel are the responsibility of the vendor. The vendor must provide calculations which demonstrate that any support rod or devices in contact with the 1.9 K portion (below the lambda plate) of the vessel during operation result in less than 0.5 Watt heat load total to the 1.9 K level.

4.6 Magnetic materials are not permitted in any part of the assembly unless explicitly approved by Fermilab in writing.

5.0 Helium Vessel design

5.1 The helium vessel shall be fabricated in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. The internal maximum allowable working pressure (MAWP) is 100 psi differential at a minimum temperature of 1.8 K. (That is 100 psia and surrounded by insulating vacuum.) The vessel shall be registered with the National Board of Boiler and Pressure Vessel Inspectors.

5.2 The inner vessel shall be capable of withstanding full internal vacuum with one atmosphere pressure on the outside with a safety factor of two (a minimum collapse pressure of 30 psid external).

5.3 A relatively thin wall (0.093 inch), which requires stiffening rings, has been chosen for the upper part of the inner vessel in order to reduce heat conduction to the 4.5 K bath. Stiffening ring details and vessel code requirements are the responsibility of the vendor.

5.4 In addition to the internal pressure, the inner vessel may be loaded by pressure from the magnet with a side force of up to 3300 lbf, the force center at 50 inches below the top plate.

5.5 At least 10 layers of MLI are required on the inner vessel for the purpose of reducing heat flux in a loss-of-vacuum accident.

5.6 Since vessel design details could affect the use of the vessel in ways not foreseen by the vendor, written approval from Fermilab of the inner vessel design details is required before vessel manufacturing.

6.0 Lambda plate assembly procedure.

6.1 The vendor provides to Fermilab the machined G-10 “Lambda Plate” with pins (1670-ME-304882), the machined stainless steel “Inner Lambda Seal-Ring” (1670-MD-304858), “Lambda Plate inserts” (1670-MD-304883), the “Outer Lambda Seal-Weldment” (1670-MD-304863), and the “Lambda Seal-Rod” (1670-MB-304894).

6.2 The G-10 lambda plate will be assembled and glued with its stainless steel inserts and stainless steel ring at Fermilab.

6.3 Fermilab will then fit the lambda plate assembly to the outer lambda seal-weldment, and locate, drill and tap the holes for the lambda plate tie-down. Fermilab will do a check of tie-down gusset deflection by measuring the torque of lambda plate tie-down rods required to provide a given deflection.

6.4 Fermilab will then return the outer lambda seal weldment to the vendor for assembly into the helium vessel.

6.5 Fermilab will keep the lambda plate assembly and tie-down rods.

7.0 Internal tubing and heat exchangers

7.1 The piping and valve scheme is shown on the Flow Schematic ME-304900.

7.2 Helium tubing in the vacuum space is to be of non-magnetic, weldable 300 series stainless steel, with all welded joints in the insulating vacuum space.

7.3 Nitrogen tubing may be copper or stainless steel.

7.4 The tubing MAWP is 115 psid. The shell-sides of the heat exchanger and the pumping line have a 100 psid MAWP.

7.5 Internal tube locations are shown on Fermilab drawings. The vendor may suggest changes, subject to Fermilab written approval.

7.6 The 3/16 inch instrumentation tubing must have at least 3 feet of length from the low-temperature end to an 80 K intercept, and another 3 feet of length from the 300 K anchor to the 80 K intercept.

7.7 Written approval from Fermilab of the piping design details is required before piping assembly.

8.0 Valves

8.1 Three (3) low-temperature control valves and two (2) low temperature check valves are included in this assembly. All three low-temperature control valves are to have bellows stem seals, 80 K thermal intercepts, and sufficient length to make the total heat load to the low-temperature end of each valve less than or equal to 1.5 Watts.

8.2 Valves must close bubble-tight with a replaceable Kel-F seal.

8.3 The 4.4 K JT valve (EV-547-4) is to be a tapered-plug control valve with a Cv = 2.0 and 100:1 equal percentage characteristic, i.e., Cv = 2.0 at 100% open and Cv = 0.20 at about 50% open.

8.4 The 2.2 K JT valve (EV-580-4) is to be a tapered-plug control valve with a Cv = 0.7 and 100:1 equal percentage characteristic, i.e., Cv = 0.7 at 100% open and Cv = 0.07 at about 50% open. We estimate normal steady-state operation to require Cv=0.02.

8.5 The bottom fill/warm-up valve (EV-549-4) is to be a tapered-plug control valve with a Cv = 6 and 100:1 equal percentage characteristic, i.e., Cv = 6.0 at 100% open and Cv = 0.6 at 50% open.
8.6 Fermilab will supply valve actuators for installation at Fermilab.
8.7 Check valves FCV-526-4 and FCV-537-4 are full-port in the forward direction, bubble-tight in the reverse direction. The purpose of the check valves is to prevent thermo-acoustic oscillations, so they are located at approximately the 20 K level in the piping temperature gradient with no flow through the check valve. Fermilab is providing a detailed design for the check valves.

9.0 Vacuum vessel design
9.1 The insulating vacuum vessel shall be designed and built using a minimum safety factor of 2 for this vessel relative to collapse (a minimum collapse pressure of 30 psid external).
9.2 A penetration in the bottom head for a removable shipping restraint is acceptable.

10.0 Process connections to the feedbox on the vacuum cover plate will be via the following:
10.1 A room-temperature helium supply pipe (1/2 inch OD.) Port A.
10.2 A vacuum insulated helium supply bayonet connection (1/2 inch). Port B.
10.3 A vacuum insulated helium pumping line (2 inch IPS pipe). This line exits the cover plate via a vacuum break. Port I.
10.4 A vacuum insulated 4.2 K helium quench line (2 1/2 inch IPS pipe). This line exits the cover plate via a vacuum break. Port D.
10.5 A vacuum insulated 4.2 K helium return bayonet connection (1/2 inch). Port E.
10.6 A helium cooldown line which exits the vacuum space via a standoff. Port M.
10.7 A vacuum insulated liquid nitrogen bayonet connection (1/2 inch). Port K.
10.8 And a gaseous nitrogen vent (1/2 inch OD.) Port F.

11.0 Process connections to the feedbox on the helium vessel cover plate will be via the following:
11.1 A vacuum insulated nitrogen supply bayonet connection (1/2 inch) to the baffle shield tube.
11.2 A nitrogen vent line from the baffle shield tube.
11.3 A primary relief pipe.
11.4 Helium will also vent through the power leads on the top plate.

12.0 Thermal shield design
12.1 The inner vessel and helium piping are to be thermally shielded with an 80 K, LN2-cooled shield made of copper as shown in the Fermilab drawings. Trace piping which will contain LN2 should be thermally attached to the shield such that all parts of the shield are less than 85 K during operation.

Modifications to this design are subject to Fermilab written approval before manufacturing.

12.2 MLI both on top of the 80 K shield and on piping under the 80 K shield may be according to the vendor's standard, subject to Fermilab approval.

12.3 The 80 K shield should be covered with 30 layers or more of MLI, a layer at least ½ inch thick.

13.0 Leak testing

13.1 Tubing shall be tested at 125% of the MAWP. All joints shall be soap and bubble checked for leakage at the test pressure.

13.2 As a final leak check the following tests shall be performed with the insulating vacuum vessel connected to a leak detector of minimum sensitivity of 2 x 10^{-9} torr-liter/sec of helium:

13.3 All joints on the outside of the vacuum vessel shall be sprayed with helium with no detectable leak.

13.4 The tubing and inner vessel shall be pressurized to 100 psia with helium with no detectable leak. The vendor may weld pipe caps on the pipe ends.

14.0 Flow testing. As a check that the piping in the final assembly is free of obstructions, the following flow tests are required. Pressure drop may be scaled with flow squared in order to match vendor's instrumentation. (See flow schematics for line definitions.)

14.1 ΔP1--Pumping line, primarily determined by the shell-side of the heat exchanger (item 2 and attached piping in "Piping Spool Details", 1670-ME-304864). A pressure drop of less than 5" water shall be seen when measured with a flow of 400 SCFM air or nitrogen at room temperature and pressure.

14.2 ΔP2--Quench/cooldown/return line (items 10 through 4 and exit nozzle on ME-304864). A pressure drop of less than 1 psid shall be seen when measured with a flow of 70 SCFM air or nitrogen.

14.3 ΔP3--Primary quench line from helium vessel through 2 ½ inch check valve (item 3 on ME-304864). A pressure drop of less than 1 psid shall be seen when measured with a flow of 230 SCFM air or nitrogen.

14.4 ΔP4--LN2 shield. A pressure drop of less than 1 psid shall be seen when measured with a flow of 2 SCFM air or nitrogen.

14.5 ΔP5—Forced flow return line. A pressure drop of less than 1 psid shall be seen when measured with a flow of 6 SCFM air or nitrogen.

14.6 ΔP6—Liquid helium supply line and top fill valve. A pressure drop of less than 1 psid shall be seen when measured with a flow of 4 SCFM air or nitrogen.

14.7 ΔP7—Liquid helium supply line and bottom fill valve. A pressure drop of less than 1 psid shall be seen when measured with a flow of 4 SCFM air or nitrogen.

14.8 ΔP8—Heat exchanger supply valve and line. A pressure drop of less than 2 psid shall be seen when measured with a flow of 4 SCFM air or nitrogen.

14.9 The vendor should call to arrange a time for these tests so that Fermilab personnel have the option to visit and witness these tests.

15.0 Documentation

15.1 The manufacturer shall provide Fermilab the code UA-1 form and certificates of mass spectrometer tests.

15.2 The manufacturer shall provide Fermilab with a written summary of flow test results.

15.3 Copies of any material certifications and material test results required in order to ensure pressure vessel code compliance must be supplied with the assembly.

15.4 The manufacturer shall provide Fermilab with copies of drawings of the inner vessel and any other vendor-designed details.

16.0 On-site inspections by Fermilab

16.1 Fermilab reserves the right to make on-site inspections of the dewar components and assembly during manufacturing.

16.2 In particular Fermilab would like to inspect the vessel piping assembly before the MLI and 80 K shield are applied, and the 80 K shield before the MLI is applied.

17.0 Fermilab-supplied material

17.1 Fermilab will provide resistance thermometers mounted on a card and wires for the vendor to install into a 3/4-inch tee or tube stub and 3/16-inch tube assembly.

17.2 Fermilab's standard vacuum parallel plate relief will be provided to the vendor to be welded into the top plate of the vacuum space.

17.3 Bellows for bore tube thermal contraction (item 11 on ME-304850 and item 5 on MD-304870) will be provided by Fermilab

17.4 Epoxy for Fermilab will provide the lambda plate assembly.

17.5 Fermilab will provide four bayonet assemblies (1 each of 1650-MD-257376-1 and MD-257376-2).

17.6 Power leads (15 kA, 600 A, and 60 A) will all be provided by Fermilab and installed on the helium vessel top plate at Fermilab.

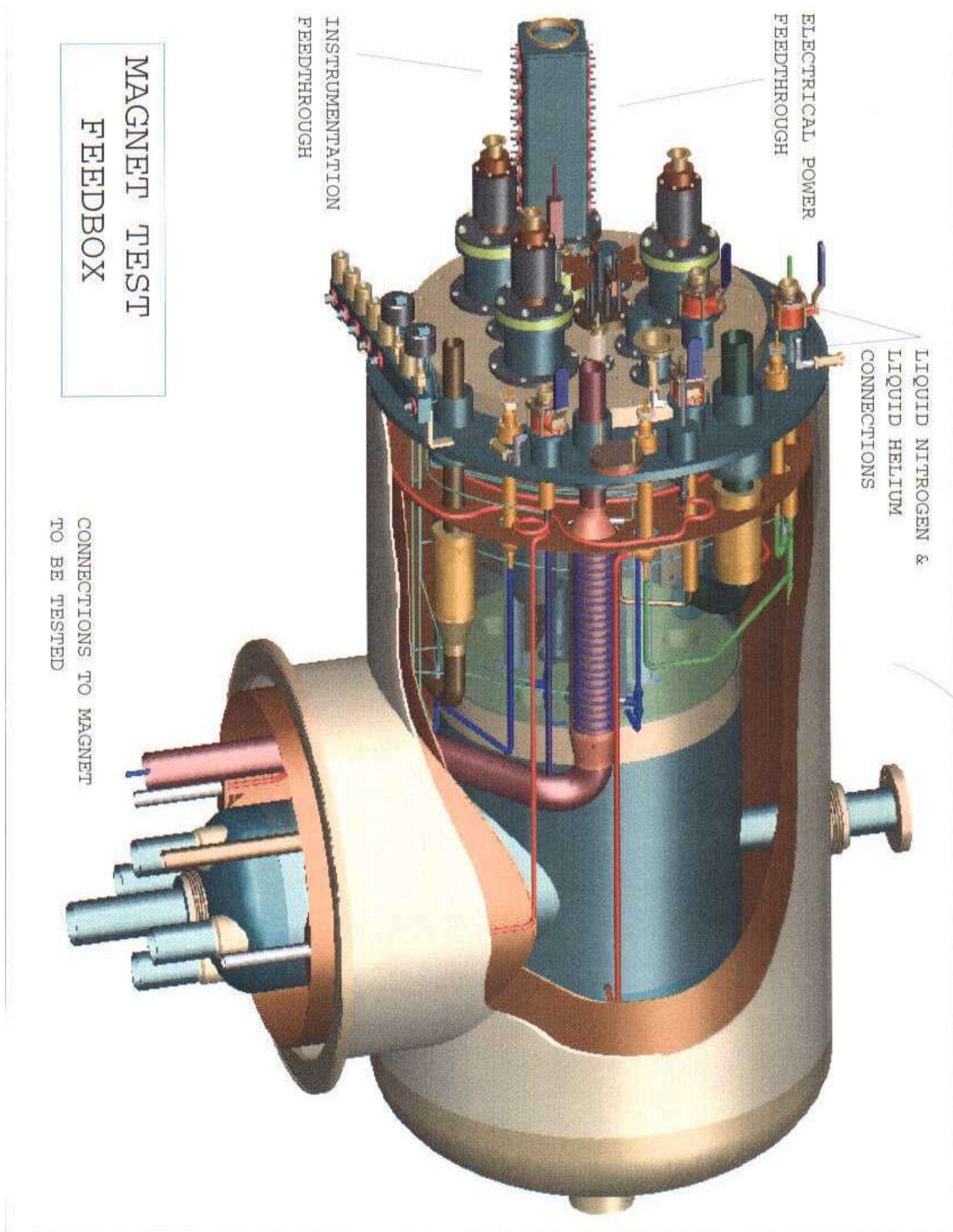
18.0 Cleaning and packaging

18.1 The final assembly must be free of grease, residue, dirt, and chips and packaged such as to ensure delivery in a clean condition. Packaging must be such as to protect the assembly from damage during shipping and handling.

18.2 Provisions (such as a removable shipping constraint) shall be provided to ship the assembly in the horizontal position while allowing operation in the vertical position.

19.0 Warranty

19.1 Manufacturer to warrant material and workmanship for a period of one year from start-up or 18 months from shipment, whichever comes first.



MAGNET TEST FEEDBOX
INSTRUMENTATION FEEDTHROUGH
ELECTRICAL POWER FEEDTHROUGH
LIQUID NITROGEN & LIQUID HELIUM CONNECTIONS
CONNECTIONS TO MAGNET TO BE TESTED

DRAWING NUMBERS	REV	DRAWING DESCRIPTION	DATE
0641-MC-23622	D	6” Bellows – 2” Long, Proton Beam Line	12-05-85
1650-MD-168678		SSC-MTF End Can Rear Flange, Mounting	2-21-86
1650-MD-257376		4-Bolt Valve Type w/o V-Rings, 1 ½” Female Bayonet Assembly	08-88
1670-MB-304753	A	Stand 4 Feed Can, 4-Pin Connector Adapter	02-16-99
1670-ME-504850		Stand 4 Feed Can- Helium Vessel Assembly	07-01-98
1670-MD-304851		Stand 4 Feed Can- J.T. Heat Exchanger-Assembly	06-24-98
1670-MD-504852		Stand 4 Feed Can- J.T. Heat Exchanger-Outer Shell	06-26-98
1670-MB-504855		Stand 4 Feed Can- J.T. Heat Exchanger-Mandrel	06-26-98
1670-MA-504854		Stand 4 Feed Can- J.T. Heat Exchanger-Nozzle	06-26-98
1670-MC-504855		Stand 4 Feed Can- 80K Shield Top Plate	09-28-98
1670-ME-504856		Stand 4 Feed Can- 80K Shell Assembly	10-22-98
1670-ME-504857		Stand 4 Feed Can-80K Shield Ass'y/Intercept Detail	09-28-98
1670-MD-304858		Stand 4 Feed Can- Inner Lambda Seal-Ring	11-11-98
1670-MD-504859		Stand 4 Feed Can- Outer Lambda Seal-Ring	06-29-98
1670-MD-504860		Stand 4 Feed Can- Pipe Support Spider	01-12-99
1670-MB-504861		Stand 4 Feed Can- 1 Phase Reducer	12-07-98
1670-ME-504862		Stand 4 Feed Can- 1 Phase Shell Assembly	07-06-98
1670-MD-504865		Stand 4 Feed Can- Outer Lambda Seal Weldment	07-06-98
1670-ME-504864		Stand 4 Feed Can- Piping Spool Details	09-08-98

1670-MD-304865		Stand 4 Feed Can- Vacuum Vessel-Top Plate	06-25-98
1670-ME-504866		Stand 4 Feed Can-Vac. Vessel-Top Pl.-Weld Details	09-08-98
1670-MC-$04867		Stand 4 Feed Can- Vacuum Break-Plate Details	09-08-98
1670-MB-504868		Stand 4 Feed Can- Coupling & Reducing Ring	11-20-98
1670-ME-304869		Stand 4 Feed Can- Vacuum Vessel Shell	07-24-98
1670-MD-504870		Stand 4 Feed Can- Vacuum Vessel Assembly	07-24-98
1670-MB-304871		Stand 4 Feed Can-Check Valve Assembly(2-1/2" Pipe)	08-04-98
1670-MB-504872		Stand 4 Feed Can- Check Valve Seat (2-1/2" Pipe)	08-04-98
1670-MB-504875		Stand 4 Feed Can- Check Valve Plunger(2-1/2" Pipe)	08-04-98
1670-MB-504874		Stand 4 Feed Can- Check Valve Adopter(2-1/2" Pipe)	08-04-98
1670-MB-504875		Stand 4 Feed Can-Check Valve Assembly(l-I/2" Pipe)	08-11-98
1670-MB-504876		Stand 4 Feed Can- Check Volvo Seat (1-1/2" Pipe)	08-11-98
1670-MB-504877		Stand 4 Feed Can- Check Valve Plunger(I-I/2" Pipe)	08-11-98
1670-MB-504878		Stand 4 Feed Can- Check Valve Adapter (I-I/2" Pipe)	08-11-98
1670-MD-504879		Stand 4 Feed Can- Helium Vessel-Top Plate	09-14-98
I 670-ME-304880		Stand 4 Feed Can- Helium Vessel-Top Plate Weldment	09-14-98
1670-MC-304881		Stand ¢ Feed Can- 80K Intercept Plate & Trace Tube	01-14-99
1670-ME-304882		Stand 4 Feed Can- Lambda Plate	09-15-98
1670-MD-304883		Stand 4 Feed Can- Lambda Plate Inserts	09-15-98
1670-ME-304884		Stand 4 Feed Can- Connector Tree Weldment	10-01-98
1670-MC-304885		Stand 4 Feed Can- Instrumentation Port-Flange	10-02-98
1670-MD-304886		Stand 4 Feed Can-Power Lead Vacuum docket-Assembly	10-14-98

1670-MB-304887		Stand 4 Feed Can-Power Lead Vacuum Jacket-Top Fig.	10-14-98
1670-MB-304888		Stand 4 Feed Can-Power Lead Vac. Jacket-Middle Fig.	10-14-98
1670-MB-304889		Stand 4 Feed Can-Power Lead Vac. Jacket-Bottom Fig.	10-14-98
1670-MB-304890		Stand 4 Feed Can- 4 Pin Connector Adapter	03-01-99
1670-MC-304891		Stand 4 Feed Can- Superfluid Relief Valve-Poppet	10-15-98
1670-MC-304892		Stand 4 Feed Can- Superfluid Relief Valve-Housing	10-15-98
1670-MC-304893		Stand 4 Feed Can- Gas Seal/Vent Port Connection	10-16-98
1670-MB-304894		Stand 4 Feed Can- Lambda Seal-Rod	10-20-98
1670-MD-304895		Stand 4 Feed Can-Vacuum Vessel interconnect Flange	01-25-99
1670-MD-304896		Stand 4 Feed Can- Temperature Sensor Feedthru	01-28-99
1670-MD-304897		Stand 4 Feed Can-Press. Transducer/Thermometer BIk.	02-12-99
1670-MD-304898		Stand 4 Feed Can- Actuator-Mounting Flange & Ass'y	02-10-99
1670-MB-304899		Stand 4 Feed Can- Lead Feedthru Plug/Draw-down Cup	02-10-99
1670-ME-304900		Stand 4 Feed Can- Flow Schematic	01-28-99
1670-MB-304901		Stand 4 Feed Can- 8 Pin Connector Adapter	02-15-99
1670-MB-304902		Stand 4 Feed Can- 19 Pin Connector Adapter	02-15-99
1670-MC-304903		Stand 4 Feed Can- Outer Lambda Seal – Tie-down Modification	03-11-99