



Coaxial Dynamics

A CDI INDUSTRIES, INC. COMPANY
SPECIALISTS IN RF TEST EQUIPMENT & COMPONENTS

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Instruction Manual

86000 Series RF Water Cooled Load Resistors



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INTRODUCTION

This manual gives you specific information on the installation, operation and service of stated models of the 86000 Series RF Coaxial Resistors. Most of the loads are field serviceable, but we recommend their return to us for repair. Mistakes can be costly compared to the low cost for our trained personnel to make the repairs and return the load to new performance specifications. Labor and packaging costs are minimal. We take the load completely apart, clean and inspect all parts, repair/replace as necessary, reassemble, water pressure test, power test, VSWR test and package the load for shipment. If new parts are required in the load (such as resistors etc.), this will be an additional cost. The average turn-around time on repairs is approximately 10 working days and generally will depend on your needs. When sending in repairs, please include: your company name and address, the operating frequency you use, fax number, telephone number and your name in case we need to talk to you about the load or obtain shipping instructions. We can accommodate most shipping methods.

SHIP TO:

Coaxial Dynamics
6800 Lake Abram Drive
Middleburg Hts., Ohio, USA 44135

For information call:

1-800-COAXIAL (1-800-262-9425)

PRECAUTIONS

CAUTION

USE ONLY CLEAR, COLORLESS, ANALYTIC OR TECHNICAL GRADE ETHYLENE GLYCOL WITH PURE TAP OR POTABLE* WATER AS A SOURCE COOLANT. DO NOT USE ANY STOP LEAK, SEALANTS, AUTOMOTIVE ANTIFREEZE OR UNION CARBIDE UCARTHERM™ IN COOLANT.

IMPORTANT

ADDITION OF ETHYLENE GLYCOL TO THE WATER REDUCES THE HEAT CAPACITY OF THE COOLING SYSTEM. COOLANT FLOW RATE MUST BE INCREASED BY AT LEAST 20% OVER MINIMUM FLOW.

CAUTION

DO NOT APPLY MORE THAN THE MAXIMUM RATED RF POWER TO THE LOAD. THIS WILL CAUSE INTERNAL DAMAGE TO THE LOAD.

- * **Potable Water:** The U.S. Health Department has established standards for potable water at a maximum of 500ppm of dissolved solids. Hard water (particularly dissolved salts) can cause damage to resistive film and load. Water condition can be adjusted by mixing distilled water in sufficient quantities with coolant water.

PRECAUTIONS

!!! DANGER !!!

THIS UNIT MUST BE TOTALLY DISCONNECTED FROM ALL RF POWER BEFORE ANY REPAIRS ARE ATTEMPTED. ANY ATTEMPT AT REPAIR WITHOUT DISCONNECTING THE POWER COULD RESULT IN POSSIBLE *FATAL ELECTRICAL SHOCK!!!*

WARNING

DO NOT APPLY POWER WITHOUT THE MINIMUM RATED FLOW OF COOLANT THROUGH THE LOAD. A SAFETY INTERLOCK SWITCH IS RECOMMENDED. EVEN A BRIEF APPLICATION OF POWER TO THE LOAD WITHOUT THE CIRCULATION OF COOLANT WILL CAUSE IMMEDIATE BURN OUT.

WARNING

THE LOAD RESISTOR CONSISTS OF A CERAMIC SUBSTRATE COATED WITH A SPECIAL RESISTIVE FILM. IF ANY DAMAGE OCCURS TO THE RESISTOR, THERE COULD BE SHARDS OR SHARP BROKEN PIECES OF CERAMIC IN THE LOAD. CARE SHOULD BE TAKEN SO THAT NO INJURIES OR CUTS WILL OCCUR.

GENERAL DESCRIPTION

The RF Water Cooled Coaxial Resistor is basically a termination-type unit having its characteristic impedance at the input end and tapered to zero impedance (short circuit) at the other end. The center conductor is a tubular resistor whose DC resistance is equal to the characteristic impedance of the line. The outer conductor of the coaxial line is a symmetrical horn-shaped enclosure, contoured logarithmically along its length to obtain a reflection-free termination. The RF dielectric medium consists of three distinct materials: the liquid coolant, the plastic water jacket and the air space.

Coolant enters the load at the electrically shorted end, flows axially down the center of the resistor tube, mushrooms over into the annular channel under the water jacket, and makes a second pass over the resistor in direct physical contact with the resistive film. Thus the coolant makes intimate contact with both the inside and outside cylindrical surfaces of the resistor, providing optimum heat transfer with minimal flow rate.

The dummy load housing is constructed of aluminum and/or brass or bronze sections whose inner surfaces are machined to a modified logarithmic taper. The stepped housing sections are held in accurate alignment with stainless steel socket head cap screws. The power dissipating resistor consists of a conductive resistive film which is deposited on a tubular ceramic substrate with silver bands fired on the ends for electrical connection. Contact to the resistor is made by silver plated spring fingers. Coolant flows through the fingers and passes directly over the resistive film. The resistor is enclosed within a plastic water jacket which is custom machined to match the body and seal the coolant flow.

I. ELECTRICAL CHARACTERISTICS

1-1 POWER RATING

All models of the 86000 series of coaxial loads are rated for continuous duty and may be operated in any position at any power level within their rating and with the proper water flow rate. *A 10-20% GREATER FLOW RATE MAY BE USED AND IS RECOMMENDED.* If the units are operated below the maximum power rating, a corresponding reduction in the coolant flow rate may be used (See Figure 4).

All loads are electrically tested prior to shipment. Testing is done at 60 Hz with input voltage and current measured on RMS meters. The (RMS) power being dissipated in the load is simultaneously checked by calorimetry. The relationship used for calculating the power dissipated in the load from the calorimetric data is: (Also see Figures 1 & 2)

$$P = 0.264 (T_2 - T_1) Q$$

Where P = Power in load in kilowatts

T_2 = Outlet water temperature °C

T_1 = Inlet water temperature °C

Q = Water flow in gallons-per-minute

WARNING

Power should never be applied before turning on the WATER FIRST and allowing sufficient time (approx. 1 minute) for complete wetting of the resistor and elimination of air bubbles. Water flow must be maintained throughout the application of power and may be turned off within 15-30 seconds after the power has been turned off. Failure to observe these precautions will result in instant failure of the resistor and possible destruction of other parts of the load.

I. ELECTRICAL CHARACTERISTICS

1-2 FREQUENCY RANGE

The 86000 series terminations are designed to match the most common high frequency transmission media - 50 ohm coaxial lines. The units are universal and operate over an extremely wide frequency range - from power line frequencies to beyond the UHF band.

1-3 IMPEDANCE

The impedance of the loads, in the language of VSWR (**V**oltage-**S**tanding-**W**ave-**R**atio), is quite independent of frequency, water flow rate and water temperature. It is almost purely resistive. For most models, the VSWR is maintained below 1.1 to 800 MHz. Below 100 MHz the input impedance can be regarded as purely resistive and equal to the DC resistance of the load. The tolerance on the DC resistance is held within 5 percent.

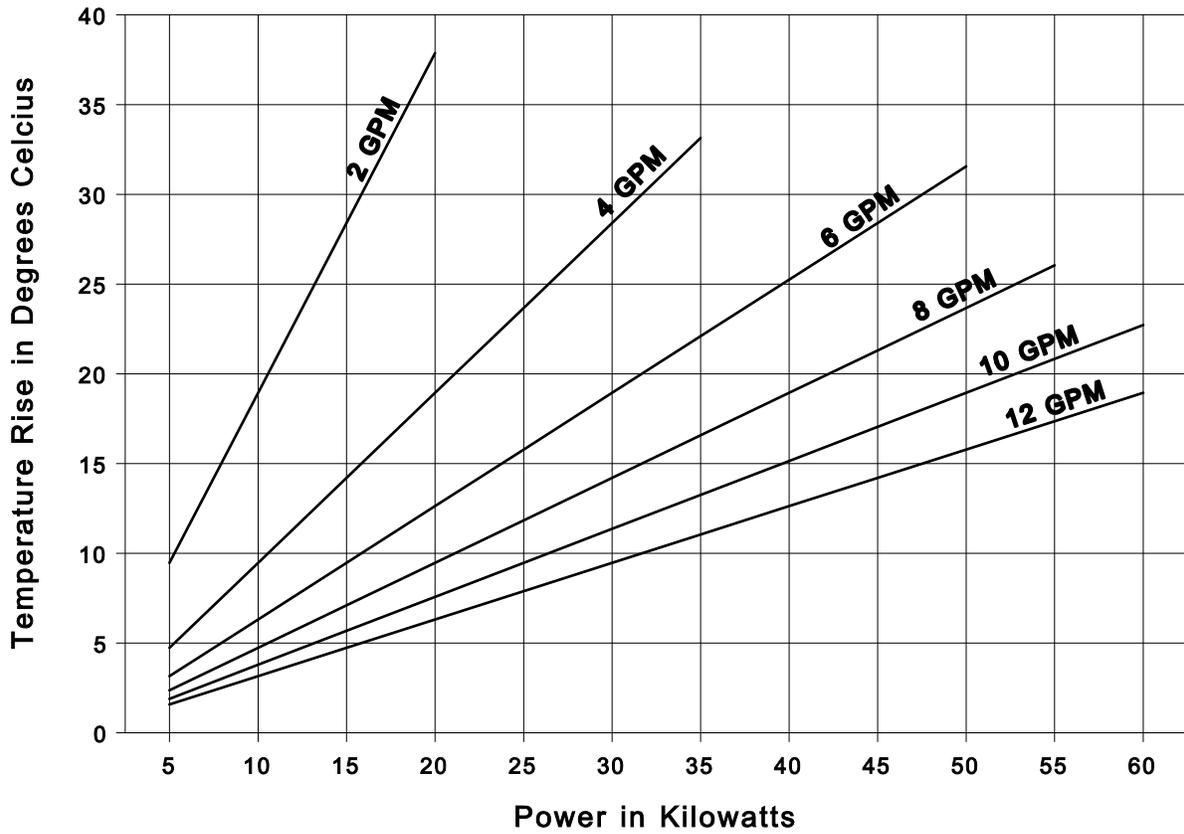


FIGURE 1 – WATER TEMPERATURE VS. POWER AT VARIOUS FLOW RATES

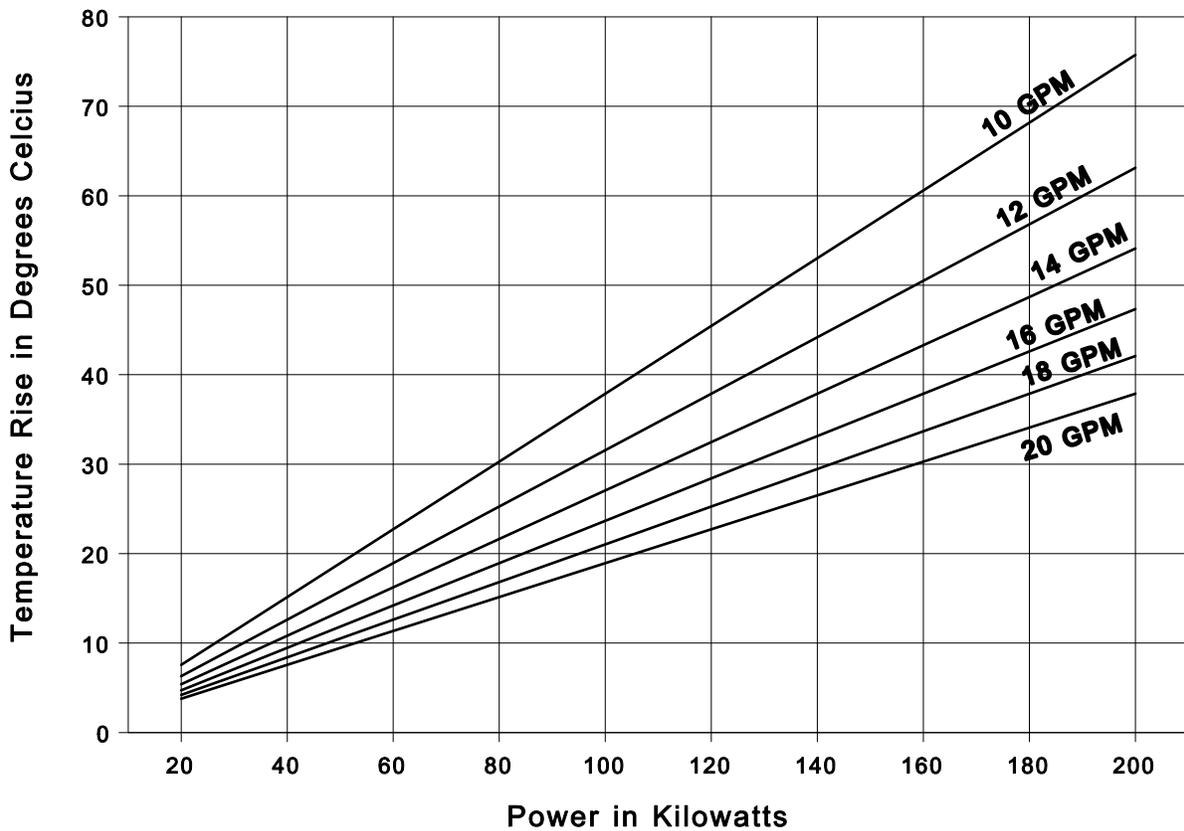


FIGURE 2 – WATER TEMPERATURE VS. POWER AT VARIOUS FLOW RATES

II. COOLING

2-1 COOLANT

The 86000 series dummy loads may be used with ordinary tap water, pure, or de-ionized water in open or closed cooling systems. The use of deionized and distilled water has been reported to cause premature failures under some conditions. These failures are the result of the leaching action of the coolant on the silver and silver-plated surfaces of the resistors and contact material. The reported failures have generally been associated with deionized systems which are polished to 10-15 megohm levels and are operated intermittently. We suspect that the failure mechanism is attributable to bacterial growth in the coolant system and the subsequent high levels of sulfides usually found in conjunction with such contamination.

Coaxial Dynamics does offer a line of water-cooled loads with gold and gold-plated resistors and contacts, for use in systems where leaching action seems unavoidable. Contact our sales office for information.

We suggest the use of caution when determining what coolant to use. Potable water is certainly the most desirable coolant. Brackish or salt water is NOT permissible as a coolant for the load resistor! The load is designed with non-contaminating elements in the water circuit and may be used with transmitters that have pure water recirculating cooling systems. For operation below the freezing temperatures of water, ethylene glycol may be added to the water to prohibit freezing (See Figure 3). If you have questions about coolants, please consult the factory.

IMPORTANT

We recommend a Glycol mixture of 40% (2:3) or less. Addition of ethylene glycol to water reduces the heat capacity of the mixture with a corresponding reduction in cooling effectiveness. Therefore, the coolant flow rate should be increased approximately 20% from that required with water only.

!!! WARNING !!!

Only clear, colorless analytic or technical grade ethylene glycol may be used. Dow Chemical Company's Dowtherm® SR1 has been reported to be fully compatible with 86000 series loads when used in accordance with Dow's instructions (up to a 40% max). **DO NOT use any stop leak, sealants, automotive antifreeze or Union Carbide Ucartherm™ in coolant.** Damage to the resistor film may occur with applied power, resulting in failure!

II. COOLING

CONCENTRATION OF COOLANT			FREEZING POINT		BOILING POINT	
Glycol: Water Parts by Volume at Room Temp	% Glycol by Volume	% Glycol by Weight	°C	°F	°C	°F
pure water	0	0	0	32	100	212
3:7	30	32.3	-16	2	104	219
2:3	40	42.7	-26	-15	106	222
1:1	50	52.7	-40	-40	109	228

FIGURE 3 - FREEZING AND BOILING POINTS OF GLYCOL-WATER MIXTURES

2-2 TEMPERATURE RANGE

The impedance of the loads is practically independent of glycol-water mixture, water flow rate, and water temperature. A wide range of input water temperatures (0°C to 60°C) may be used as long as the output water temperature is not allowed to exceed 90°C.

2-3 WATER FLOW RATE

The water flow rates specified for the loads are given as the least amount of water flow permissible for full power rating. ***At least the minimum flow of water must be maintained throughout the application of power.*** A greater flow rate (approx. 10% higher) should be used and is recommended. When used at lower than rated power, a reduced water flow rate may be used and combinations of power and water flow rates may be determined by using the table of Figure 4. In all cases, ***water must be allowed to flow for about 1 minute before applying power*** so that all air bubbles are dispelled from the system.

MODEL(S)	MINIMUM WATER FLOW RATE	MAXIMUM AVERAGE (RMS) POWER *	GALLONS PER KILOWATT (K _f)
86005 – 86007	2 GPM	5 kW	.40
86017 – 86018	4 GPM	15 kW	.27
86027 – 86029	6 GPM	25 kW	.24
86052 – 86054	10 GPM	50 kW	.20
86080 – 86082	10 GPM	80 kW	.125
86125 – 86127	15 GPM	125 kW	.12
86200	19 GPM	200 kW	.095
* Single Frequency CW			

FIGURE 4 - MINIMUM WATER FLOW RATE REQUIREMENTS

To determine the water flow rate requirements at lower power levels, multiply the average input power in kilowatts by the water flow rate coefficient (K_f) from the above table for the model being used, and add 20% for ethylene glycol mixtures.

II. COOLING

2-4 WATER PRESSURE

The table of Figure 5 gives the maximum allowable inlet pressure for each model. Continuous operation of the loads at full power and up to an outlet water temperature of 90°C is permissible within the maximum operating pressures given in the table.

NOTE: Do not use a shut-off valve on the water output side of the load in systems that have no water expansion pressure relief. Pressure in the outlet line should be as low as possible to minimize internal pressure.

MODEL(S)	INTERNAL PRESSURE DROP	MINIMUM FLOW RATE	ORIFICE COEFFICIENT (K _o)	MAXIMUM INLET PRESSURE
86005 – 86007	6 PSI	2 GPM	1.5	75 PSI
86017 – 86018	12 PSI	4 GPM	.75	100 PSI
86027 – 86029	13 PSI	6 GPM	.36	100 PSI
86052 – 86054	30 PSI	10 GPM	.30	100 PSI
86080 – 86082	25 PSI	10 GPM	.25	100 PSI
86125 – 86127	25 PSI	15 GPM	.11	100 PSI
86200	50 PSI	19 GPM	.14	100 PSI

FIGURE 5 - INTERNAL PRESSURE DROP VS. FLOW RATE

To determine the pressure drop at other flow rates, use the orifice coefficient (K_o) from the above table in the following equation for the model being used:

$$\text{PSI} = K_o Q^2$$

Where PSI = Internal pressure drop in lbs/in²

K_o = Orifice coefficient

Q = Coolant flow rate in gallons/minute

III. COOLING SYSTEMS

3-1 TYPES OF COOLING SYSTEMS

Four basic cooling systems are summarized in the table of Figure 6; viz., municipal water, natural water, tank or reservoir, and heat exchanger. No single cooling system is the "best" under all the different circumstances and conditions encountered by the field. Closed loop systems are generally preferable since they afford much greater control over the purity, temperature, pressure, and flow rate of the coolant.

METHOD	COOLANT	COOLANT SOURCE	BASIC COMPONENTS NEEDED			HOURS OF CONTINUOUS OPERATION
			COOLANT LINES & GAUGES	PUMP	RESERVOIR	
Open	Tap Water	Municipal Supply System	✓	In low flow areas	Optional	Unlimited
	Natural Fresh Water	Lake, River, Pond, etc.	✓	✓	Optional	Unlimited
Closed	Tap or Distilled Water with or without Glycol	Storage Tank	✓	✓	100 to 1500 Gallons	Up to 8 hrs. See Figure 7
	Tap or Distilled Water with or without Glycol	Accumulator	✓	✓	1 to 5 Gallons	Unlimited
	Tap or Distilled Water with or without Glycol	Air-Cooled Core	✓	✓	Optional	Depending on BTU Capacity of Exchanger

FIGURE 6 - ALTERNATIVE COOLING SYSTEMS

3-2 TAP-WATER SYSTEM

The most convenient way to cool the load resistor at the lowest initial cost is by tapping into the existing water supply on the premises. Most municipal sources can provide sufficient pressure to obtain a flow rate that will cool even the highest power model.

In the absence of a water flow-meter, a measure of the available flow rate in gallons-per-minute (GPM) may be made with a stop-watch or a watch with a sweep-hand and a gallon container. Connect the dummy load to the water faucet with a short length of hose, and with the faucet full-on, observe the time in seconds required to fill the gallon container at the water outlet of the load.

When using the dummy load with a tap-water system, the flow rate is usually adjusted to 10-15% above the minimum requirement and left unattended. Since water lines ordinarily serve other appliances (flush toilets, etc.) over which there is no control, a flow switch should be installed to protect the load resistor element in case the flow rate

III. COOLING SYSTEMS

drops due to a momentary change in water pressure. Choose a flow switch with a small "ON-OFF" flow rate dead band. The switch will also protect the resistor in cases where the RF power may be turned on before the water flow, or where accidental termination of water flow (pinched hose, debris, valve closing, etc.) may occur. In the tap-water system the heated water is discharged down the drain and therefore, the cost of the water becomes an important consideration.

3-3 NATURAL WATER SYSTEM

A close proximity to a natural supply of fresh water may suggest its utilization. Brackish or salt water may NOT be used as a coolant for the load resistor. The natural water system usually requires more extensive piping and heavier pumping equipment to handle attendant pressure drop.

In this system, the water from the natural source may not be directly usable as a coolant for the load resistor element due to a high contamination, such as silt, iron content, mud, etc.; but it may be used as "dirty" water coolant in a water-to-water heat exchanger. The contaminated water could be piped via plastic tubing or hose to copper coils immersed in a holding tank containing clean water coolant for the dummy load. This arrangement would require a dual pump - one section to pump the "dirty" natural-source water and the other section to pump the clean water coolant through the dummy load.

The quality of natural water varies widely and straining is often necessary to handle the twigs, minnows, leaves and other debris frequently encountered. Small automatic self-cleaning strainers are available for this purpose. The strainer should be installed upstream from the pump to protect the pump as well as the load resistor. Additional filtering of smaller particles is sometimes required and this can be accomplished with finer mesh "Y-TYPE" strainers inserted in series with the line.

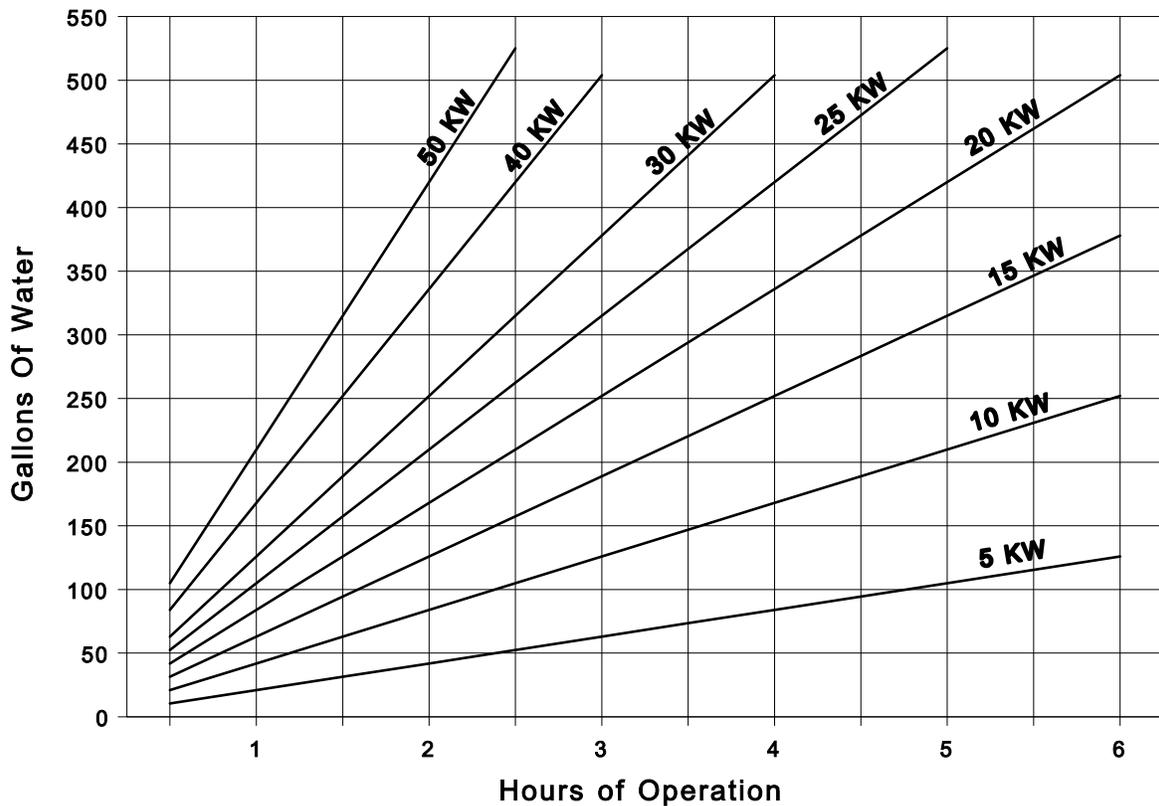
3-4 HEAT EXCHANGER SYSTEM

In this system, an accumulator or receiving tank is used which only holds about one-half the flow rate in gallons-per-minute. Accordingly, a small quantity of coolant is required. The coolant functions solely as a heat transfer agent between the load resistor and the heat sink. A heat exchanger consisting of a radiator and a fan is the type recommended for this application. With ambient air as the ultimate heat sink, the operating temperature of the coolant will always be above the air temperature for heat to be transferred from the load to the air. Some consideration should be given to exhausting the hot air to the outside so as not to have a temperature rise problem in the transmitter area. The heat exchanger may be a complete self-contained unit (portable) which includes the dummy load or the load may be separate and apart from the heat exchanger unit to facilitate installation and maintenance requirements, etc. Both types of heat exchanger packages are available from us.

III. COOLING SYSTEMS

3-5 TANK OR RESERVOIR SYSTEM

In this system, a practical amount of coolant is stored in a tank or reservoir and continuously recirculated (pumped) through the load until the coolant becomes hot. **(NOTE: One kilowatt of power will raise a gallon of water 7°F per minute.)** This relationship is used to calculate the graph in Figure 7. The curves show the permissible hours of continuous operation for a given quantity of water in gallons, i.e., the number of gallons of water that will be raised from room temperature (70°F) to 170°F. The water flow rate as specified for each load (GPM) must be maintained throughout the application of power. A thermal switch and a water flow switch should be used as a protection against over-temperature and low coolant flow.



NOTE: 80 kW Load = 40 kW ÷ 2
100 kW Load = 50 kW ÷ 2
200 kW Load = 50 kW ÷ 4

FIGURE 7 – GALLONS OF WATER VS. HOURS OF OPERATION

III. COOLING SYSTEMS

Storage tanks between 200 and 500 gallons will satisfy most requirements. A waterproof concrete holding tank in the 1000 to 1500 gallon range may also be considered (similar to a septic tank and buried below the frost line). It would be protected from the extremes of temperature and could hold ordinary tap water as the coolant, while comparing favorably in cost to smaller metal tanks exposed to the elements. Storage tanks are normally vented to the atmosphere and allowance should be made for determining the liquid level in the tank and for adding make-up water. Some typical sizes of tanks in the range of interest are shown in Figure 8 below.

Capacity (in Gallons)	Size (in Feet) Diameter x Length
120	2 x 5
200	2.5 x 5.5
300	3 x 6
500	3.5 x 7
1000	5 x 7
1500	5 x 10.5

FIGURE 8 - TANK SIZES

The pump selected for this service should have all wetted parts made from brass, bronze, ceramic or stainless steel. Cast iron and common steel will "poison" the water system and cause early failure of the load. Select the pump to overcome piping losses and the internal pressure drop of the load. The internal pressure drop of each model of the 86000 series loads is shown in the table of Figure 5.

IV. INSTALLATION

The 86000 series loads may be used on both fixed and portable applications and they perform equally well in any mounting position. The units are very rugged and light and may be strapped, clamped, or secured with any practical and readily available mechanical device. They may be held by the RF connector on one end and by the plumbing on the other end. The coolant may be allowed to pass through the load in either direction without affecting its operation, but the axial water connector is normally used as the inlet since it contains the built-in filter screen.

Water lines connecting the load should be 3/4" copper water tubing and rigid enough to support the load. (*NOTE: A fifty-foot length of 1/2" pipe has a pressure drop of 45-PSI at 10-GPM water flow rate, while a 3/4" pipe under the same conditions only develops a 5-PSI drop.*) In typical installations, the rigid piping is terminated within a few feet of the load, and flexible hose is used to bridge the last few feet. The hose should be 3/4" I.D. and capable of withstanding the temperature and pressure of the system.

The water fittings on the load are 3/4" hose thread to accommodate standard hose couplings. Do not screw pipe thread fittings onto the hose thread - damage will result due to cross-threading. Pipe threads are tapered and hose threads are straight. If it is desired to mate with regular 3/4" pipe threads, use a hose-to-pipe adapter. The adapter is recommended since it eliminates the need of removing the side outlet water fitting and also allows the axial water fitting to be adapted directly to 3/4" pipe. The adapters may be obtained at a local hardware store or a plumbing supply house.

Provisions should be made to allow interruption of the transmission line at any position where the transmitter is to be terminated by the load or measurements are contemplated. Coaxial switches may be inserted in the transmission line run to provide rapid load switching. Proceed as follows:

1. Install the unit in the selected location.
2. Connect the outlet water fitting of the dummy load to a convenient drainage.
3. Connect the water inlet to a water source capable of delivering the required flow in gallons-per-minute.

If the required source of water flow is not available from the local lines, refer to the previous section for a possible alternate cooling system. We highly recommend the use of a flow switch in the inlet piping to detect low flow conditions which could damage the load. We recommend the IMO DeLaval Model AFS200, Adjustable Flow Switch. This switch has low internal pressure drop and operates reliably in pilot-duty applications. (This switch is available from us.) Mount the switch in a horizontal section of pipe where there is a straight horizontal run of at least five inches on each side of the switch.

4. Connect the microswitch contacts of the flow switch in series with transmitter interlock circuit.
5. Connect the dummy load to the transmission line. The unit is designed to connect to a 50 ohm line.

V. OPERATION

To place the dummy load in operation, the following procedure is recommended:

1. Turn on the water pressure and make certain water is flowing through the load. Allow about 1 minute of water circulation to insure complete wetting of the resistor element in the load and exhaustion of air bubbles.
2. Check the water flow rate. This can be done with a gallon container and a wrist-watch with a sweep-hand if no water flow meter is available.
3. Apply RF power.

To cease operation, turn the RF power off and allow about 30 seconds before turning off the water.

VI. CALORIMETRY

The 86000 series loads may be used in conjunction with a flow meter, thermometer wells and thermometers to accurately measure transmitted power by calorimetry. Figure 9 shows a complete arrangement. The flow meter and the thermometer wells may be placed at a convenient position and at eye level for ease of reading. There is no need to have them adjacent or in close proximity to the load. The components may be placed upwards of fifty feet away from the load without any loss in the accuracy of measurement.

The thermometer wells, which are closed to the main coolant stream, use water as the heat transfer medium and operate efficiently with the thermometers immersed in about 1 inch of water. The stabilization time for the system is approximately thirty seconds and a power measurement accuracy within 2% may be obtained with very little difficulty. Figures 1 and 2 show the temperature rise as a function of power in kilowatts (kW) for various water flow rates in gallons-per-minute (GPM). Technical and component information on the calorimetry setup may be obtained by contacting the factory.

If an ethylene-glycol and water mixture is used, a correction must be applied to the flow meter reading due to a change in density and change in specific heat and gravity of the coolant.

Use the curves of Figure 10 to obtain the new (K_t) multiplying factor for the calorimetric power equation and curves of Figure 11 to obtain the density value to be used with the curve of Figure 12 to get the flow meter correction factor. The calorimetric power equation when using ethylene glycol and water mixtures will be as follows:

VI. CALORIMETRY

$$P = K_t (T_1 - T_2) Q \times F$$

Where P = Power in load in kilowatts

T₁ = Outlet water temperature °C

T₂ = Inlet water temperature °C

Q = Water flow in gallons per minute

F = Flow meter correction factor

K_t = Coolant multiplying factor

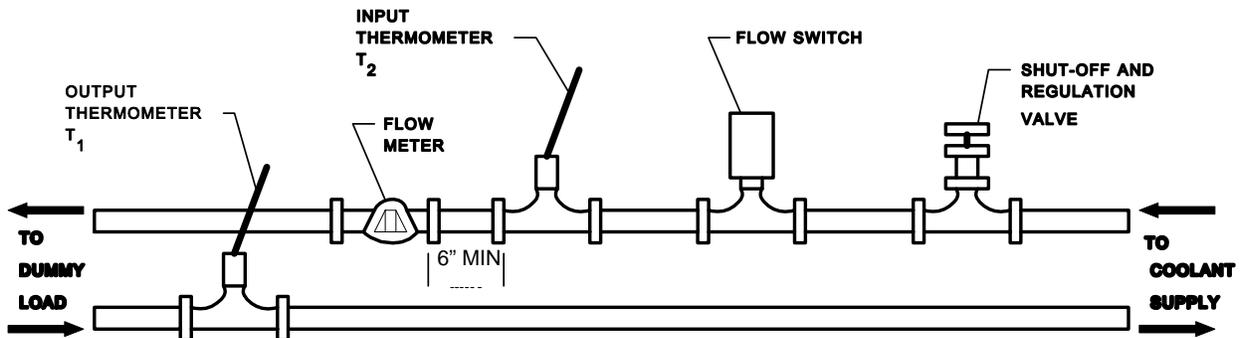


FIGURE 9 – CALORIMETRY SETUP

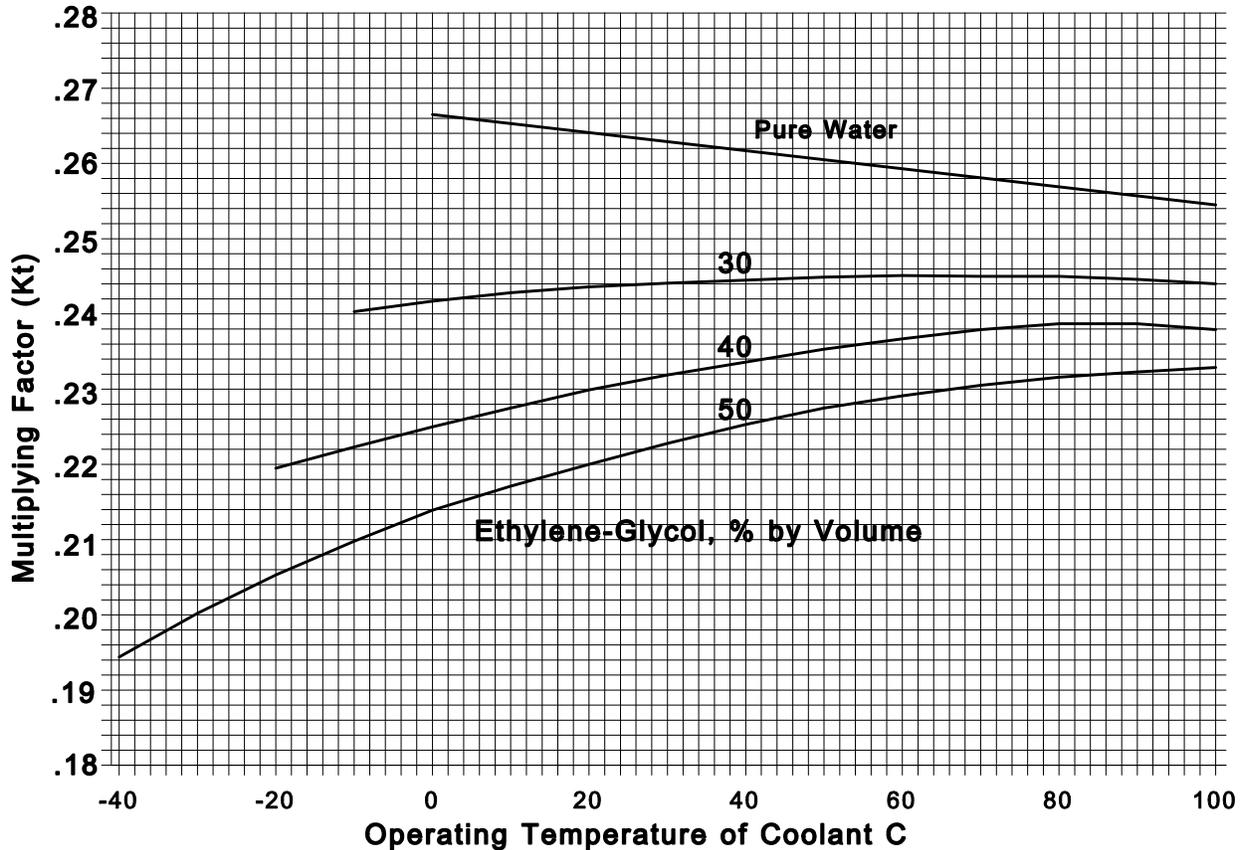


FIGURE 10 - K_T FOR ETHYLENE-GLYCOL/WATER MIXTURES VS. TEMPERATURE

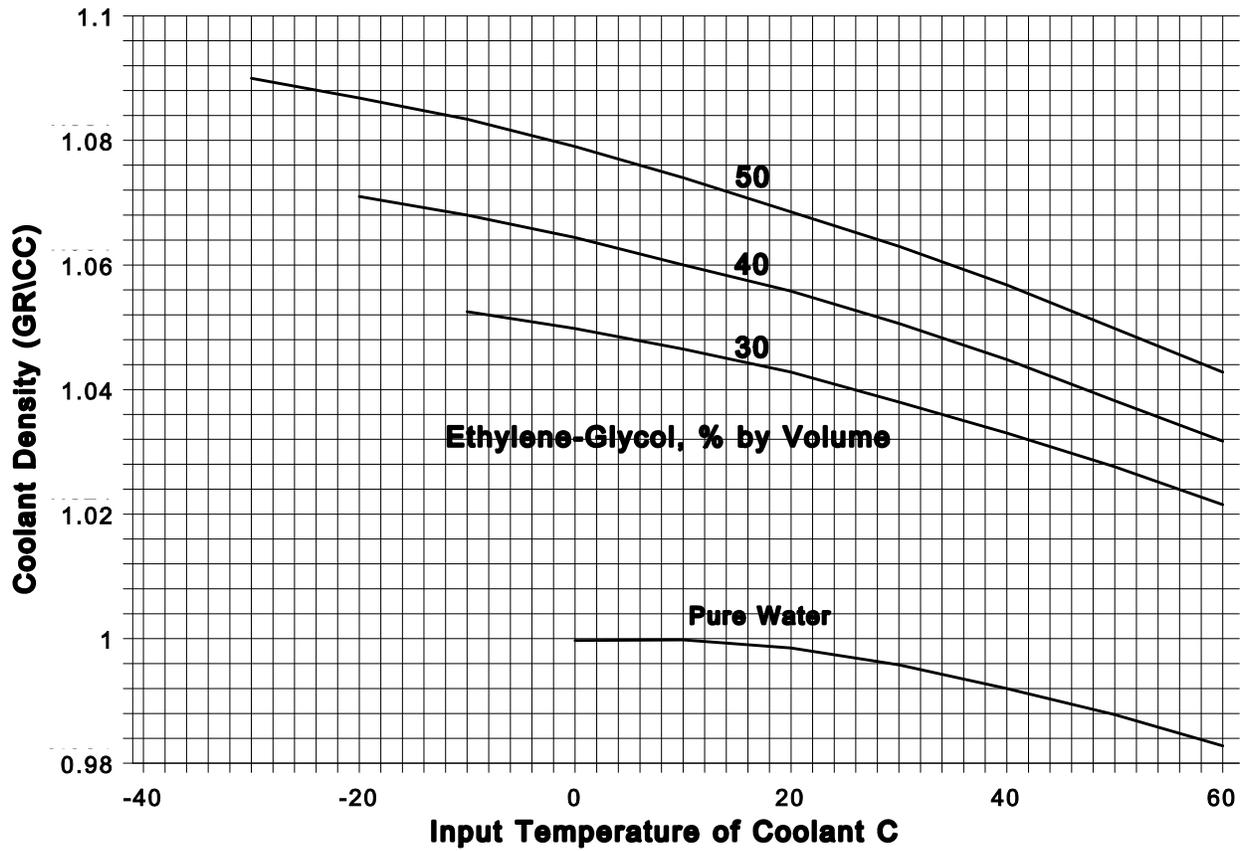


FIGURE 11 – DENSITY OF ETHYLEN-GLYCOL MIXTURES VS. TEMPERATURE

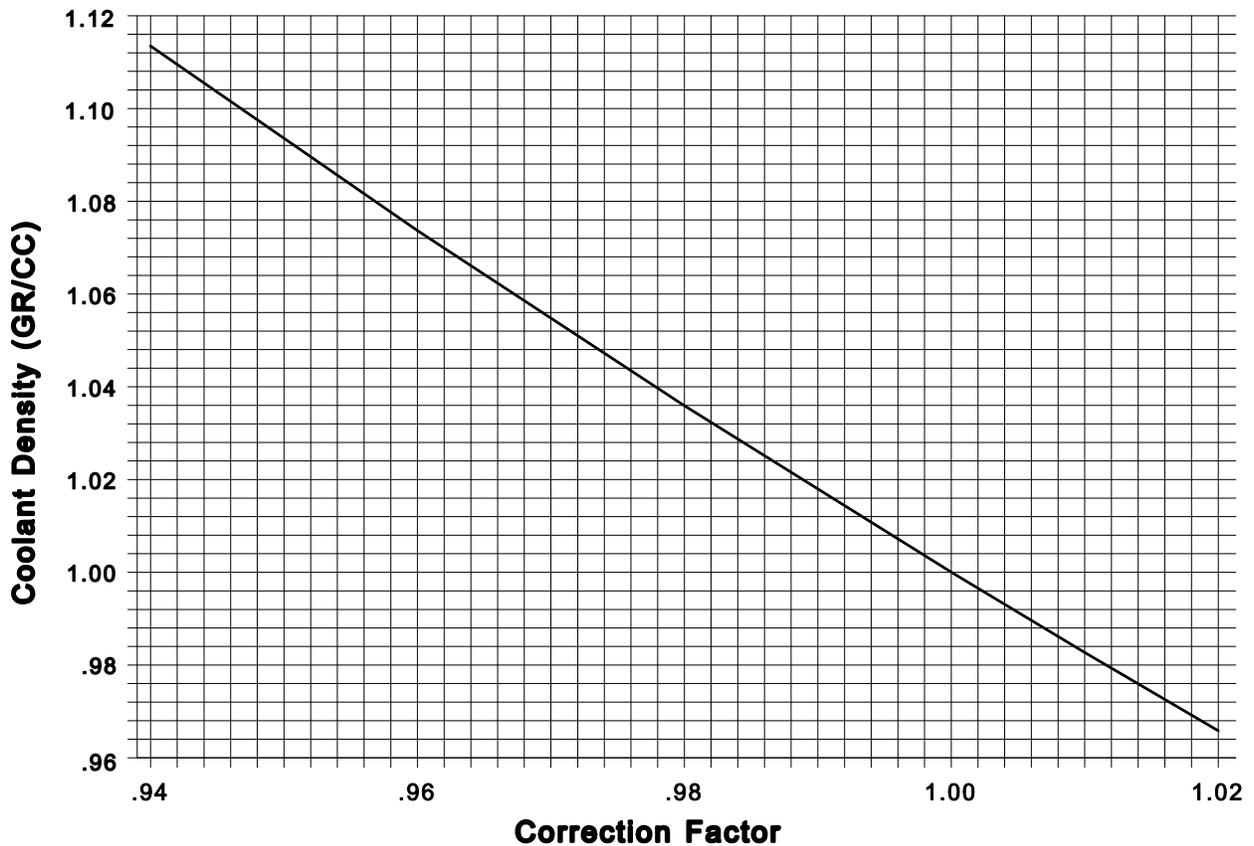


FIGURE 12 – FLOW METER CORRECTION FACTOR

VII. SPECIFICATIONS

MODEL NUMBER	86005 to 86007	86017 to 86019	86027 to 86029	86052 to 86054
Impedance	50 ohm nominal			
Maximum Power Rating	5 KW	15 KW	25 KW	50 KW
Effective Frequency Range	60 Hz to 800 MHz			
Maximum VSWR	1.10 to 800 MHz; 1.2 to 1.0 GHz			
Coolant	Ordinary tap water, pure water or technical grade Ethylene-Glycol and water mixture 50%			
Water Connectors	3/4" Garden Hose			
Minimum Water Flow Rate	2 GPM	4 GPM	6 GPM	10 GPM
Input Water Temperature	4°C to 60°C			
Output Water Temperature	90°C Maximum			
Maximum Inlet Pressure	75 PSI	100 PSI		
Resistor	Cylindrical film type - field replaceable			
Input Connectors	QM Conn. 1-5/8" 3-8"	QM Conn. 1-5/8" 3-8"	3-1/8" 4-1/16" 6-1/8"	
Nominal Dimensions (Max.)	10-1/4" x 3-1/2"	14-3/8" x 5-1/4"	15-1/2" x 8-1/8"	17-5/8" x 8-1/8"
Nominal Weight (Max.)	4-1/2 lbs.	9-1/2 lbs.	13 lbs.	16-1/2 lbs.
Operating Position	Any			
Finish	Conversion Coating and Nickel Plate			

DC Resistance _____ Model _____ Date _____

VII. SPECIFICATIONS

MODEL NUMBER	86080 to 86082
Impedance	50 ohm nominal
Maximum Power Rating	80 KW
Effective Frequency Range	60 Hz to above 1200 MHz
Maximum VSWR	Less than 1.15 to 800 MHz
Coolant	Ordinary tap water, pure water or technical grade Ethylene-Glycol and water mixture 50%
Water Connectors	3/4" Garden Hose
Minimum Water Flow Rate	10 GPM
Input Water Temperature	4°C to 60°C
Output Water Temperature	90°C Maximum
Maximum Inlet Pressure	100 PSI
Resistor	Cylindrical film type - field replaceable
Input Connectors	3-1/8" 4-1/16" 6-1/8"
Nominal Dimensions (Max.)	28-1/2" x 8-1/8"
Nominal Weight (Max.)	24 lbs.
Operating Position	Any
Finish	Conversion Coating and Nickel Plate

DC Resistance _____ Model _____ Date _____

VII. SPECIFICATIONS

MODEL NUMBER	86125 to 86127	86200
Impedance	50 ohm nominal	
Maximum Power Rating	125 kW	200 kW
Effective Frequency Range	60 Hz to 800 MHz	60 Hz to 450 MHz
Maximum VSWR	1.15 to 800 MHz	1.15 to 450 MHz
Coolant	Ordinary tap water, pure water or technical grade Ethylene-Glycol and water mixture 50%	
Water Connectors	NPTF Female	
Minimum Water Flow Rate	15 GPM	19 GPM
Input Water Temperature	4°C to 45°C	
Output Water Temperature	90°C Maximum	
Maximum Inlet Pressure	100 PSI	
Resistor	Cylindrical film type - field replaceable	
Input Connectors	3-1/8" 4-1/16" 6-1/8"	
Nominal Dimensions (Max.)	31" x 8-1/8"	42" x 8-1/8"
Nominal Weight (Max.)	36 lbs.	48 lbs.
Operating Position	Any	
Finish	Conversion Coating and Nickel Plate	

DC Resistance _____ Model _____ Date _____

VIII. MAINTENANCE

The 86000 series loads will require little in the way of maintenance. Components located inside the unit other than the resistor element and the filter screen are not subject to field maintenance. The resistor is field replaceable in those instances where there is no extensive damage to the resistor contacts or rupture of the teflon water jacket, due to improper operation of the load. In the event of mechanical damage to the unit, operational difficulty, or information concerning a desired unusual application of the load, contact the factory.

NOTE: Any leak from the main body of the load is an indication that the unit should be returned to the factory for repairs.

The following checks, tests and procedures may be used periodically, when necessary, or when a malfunction is suspected.

1. **DC Resistance** - The DC resistance of the load may be checked at the RF input connector and a value within 10% of the required resistance is acceptable.
2. **Filter Screen** - The flanged water connector located at the rear of the load is equipped with a cone-shaped brass screen to prevent the entrance of foreign particles into the water circuit of the load. (Back flushing may be used to clean out foreign materials trapped in the screen.) If it becomes necessary to remove the screen, remove three socket head screws to disengage the flanged water fitting to gain access to the screen.
3. **VSWR** - The voltage-standing-wave-ratio of the load is the same with "stand still" water as it is with flowing water. To test for VSWR, fill the load with water. When filling the load with water, many small bubbles will form inside. These **must** be flushed out with excess water before measuring VSWR. After filling, cork it, connect to a slotted line or directional coupler and measure the VSWR at SIGNAL GENERATOR LEVELS ONLY.
4. **Resistor Replacement** – See the following pages for individual Models. (*For Models not listed, please consult factory.*)

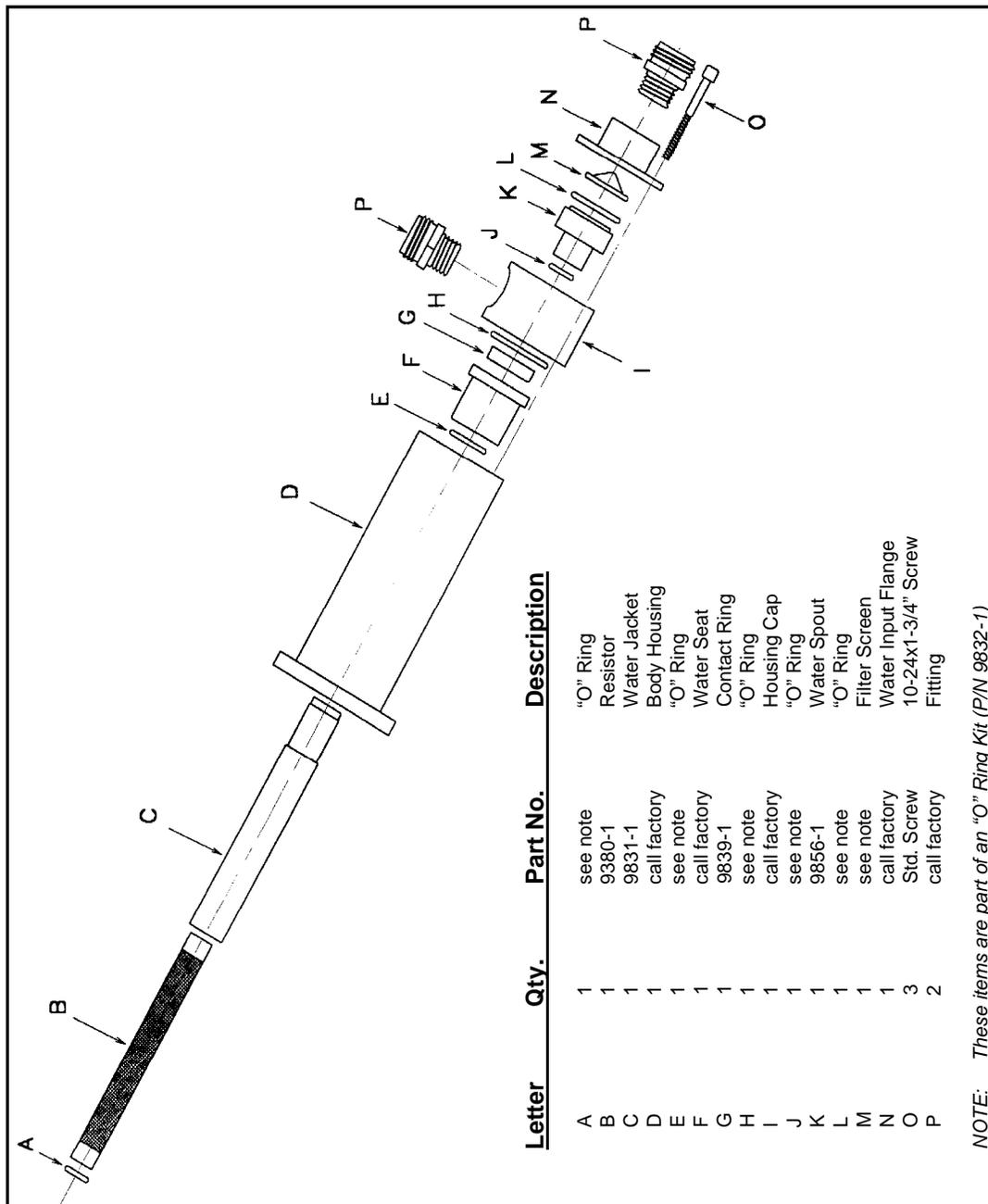


FIGURE 13 - RESISTOR REPLACEMENT FOR 5 KW MODELS

Resistor Replacement - (Refer to Figure 13) To replace the resistor element, remove the three 10-24x1-3/4" cap screws (item O). Remove water input assembly (items M, N, and P). Inspect filter screen for damage, replace if eroded or torn. Remove housing cap assembly (items G, H, I, P, J, K and L). Inspect all O-rings for distortion or damage. Replace if pinched, cut, burned or no longer round in cross section. Inspect ring contact (item G) for signs of arcing or loss of silver in the area of contact with the resistor contact band. Replace if damage is noted. If resistor (item B) is not broken, grasp by the end extending from the water seal (item F) and pull it straight out of the load. (If resistor is broken, complete disassembly of load is necessary.) Inspect the silver contact band on the RF input end of the resistor element for signs of arcing or loss of silver as an indication of the condition of the front resistor contact. Visually inspect the inside of the water jacket and front resistor contact for any signs of overheat or damage. Any sign of internal damage indicates further disassembly and repairs are necessary.

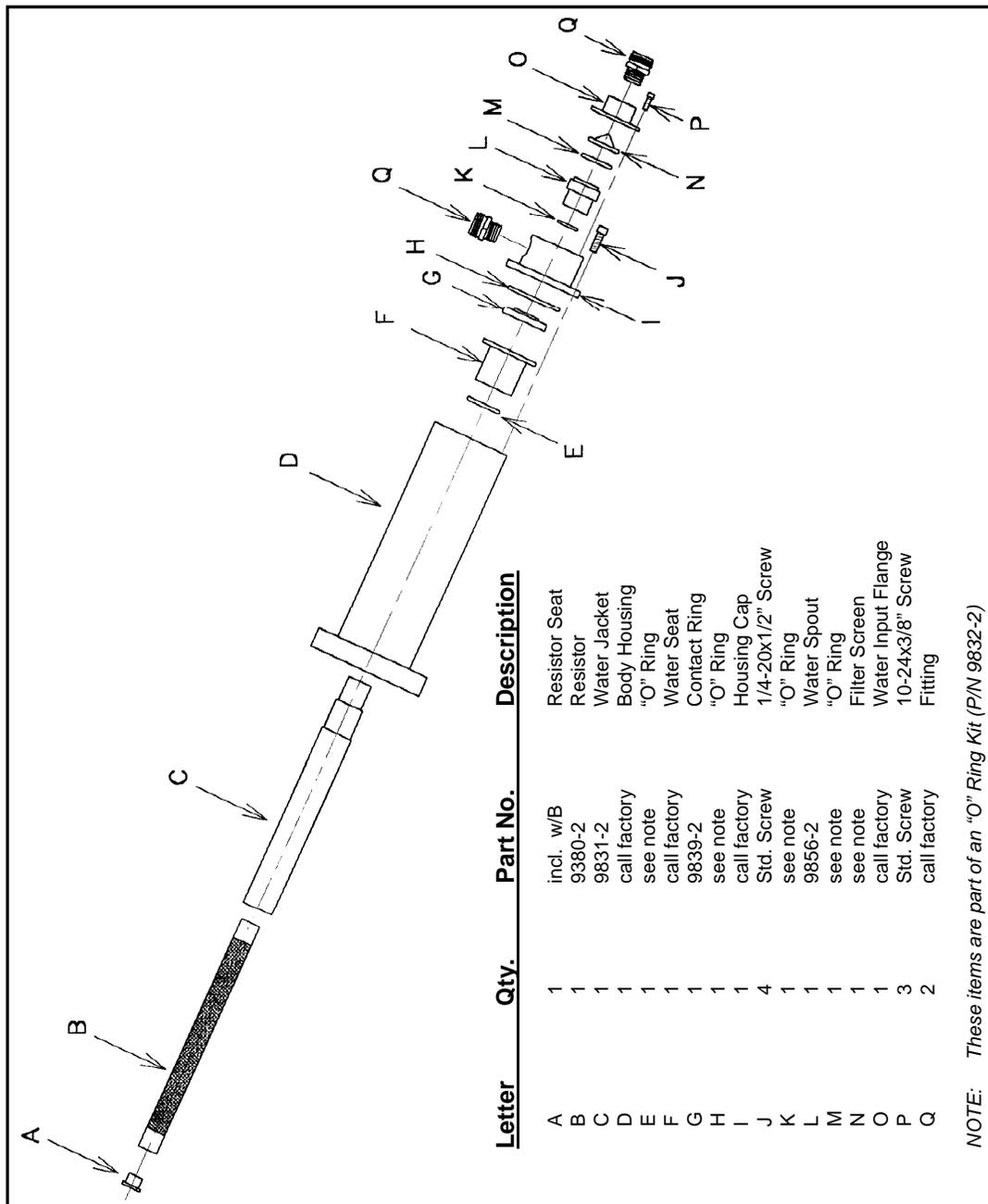


FIGURE 14 - RESISTOR REPLACEMENT FOR 15 kW MODELS

Resistor Replacement - (Refer to Figure 14) To replace the resistor element, remove the three 10-24x3/8" cap screws (item P). Remove water input assembly (items N, O, and Q). Inspect filter screen for damage, replace if eroded or torn. Remove four 1/4-20x1/2" cap screws (item J). Remove housing cap assembly (items G, H, I, Q, K, L and M). Inspect all O-rings for distortion or damage. Replace if pinched, cut, burned or no longer round in cross section. Inspect ring contact (item G) for signs of arcing or loss of silver in the area of contact with the resistor contact band. Replace if damage is noted. If resistor (item B) is not broken, grasp by the end extending from the water seal (item F) and pull it straight out of the load. (If resistor is broken, complete disassembly of load is necessary.) Inspect the silver contact band on the RF input end of the resistor element for signs of arcing or loss of silver as an indication of the condition of the front resistor contact. Visually inspect the inside of the water jacket and front resistor contact for any signs of overheat or damage. Any sign of internal damage indicates further disassembly and repairs are necessary.

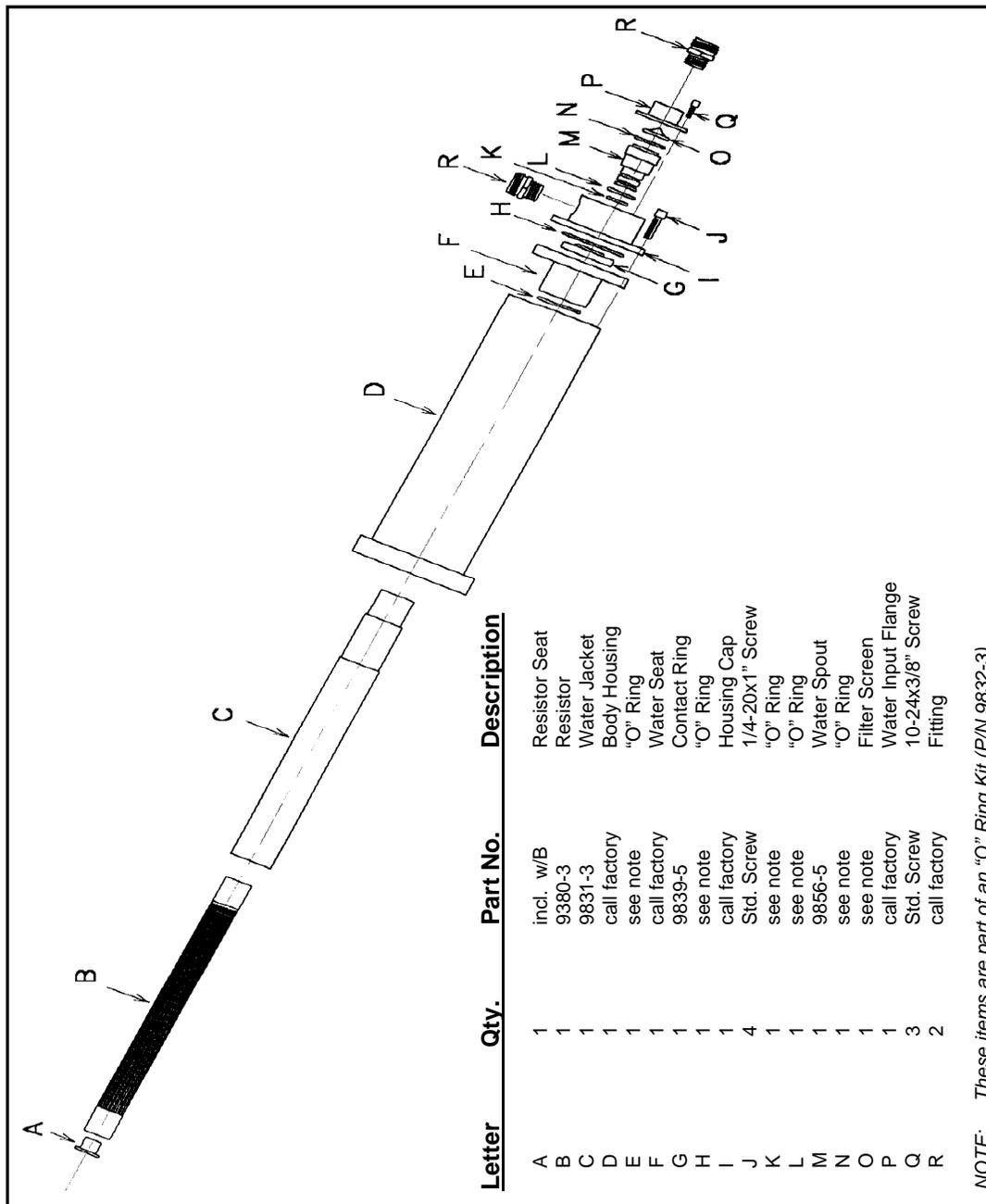


FIGURE 15 - RESISTOR REPLACEMENT FOR 25 kW MODELS

Resistor Replacement - (Refer to Figure 15) To replace the resistor element, remove the three 10-24x3/8" cap screws (item Q). Remove water input assembly (items O, P, and R). Inspect filter screen for damage, replace if eroded or torn. Remove four 1/4-20x1" cap screws (item J). Remove housing cap assembly (items G, H, I, R, K, M and N). Inspect all O-rings for distortion or damage. Replace if pinched, cut, burned or no longer round in cross section. Inspect ring contact (item G) for signs of arcing or loss of silver in the area of contact with the resistor contact band. Replace if damage is noted. If resistor (item B) is not broken, grasp by the end extending from the water seal (item F) and pull it straight out of the load. (If resistor is broken, complete disassembly of load is necessary.) Inspect the silver contact band on the RF input end of the resistor element for signs of arcing or loss of silver as an indication of the condition of the front resistor contact. Visually inspect the inside of the water jacket and front resistor contact for any signs of overheat or damage. Any sign of internal damage indicates further disassembly and repairs are necessary.

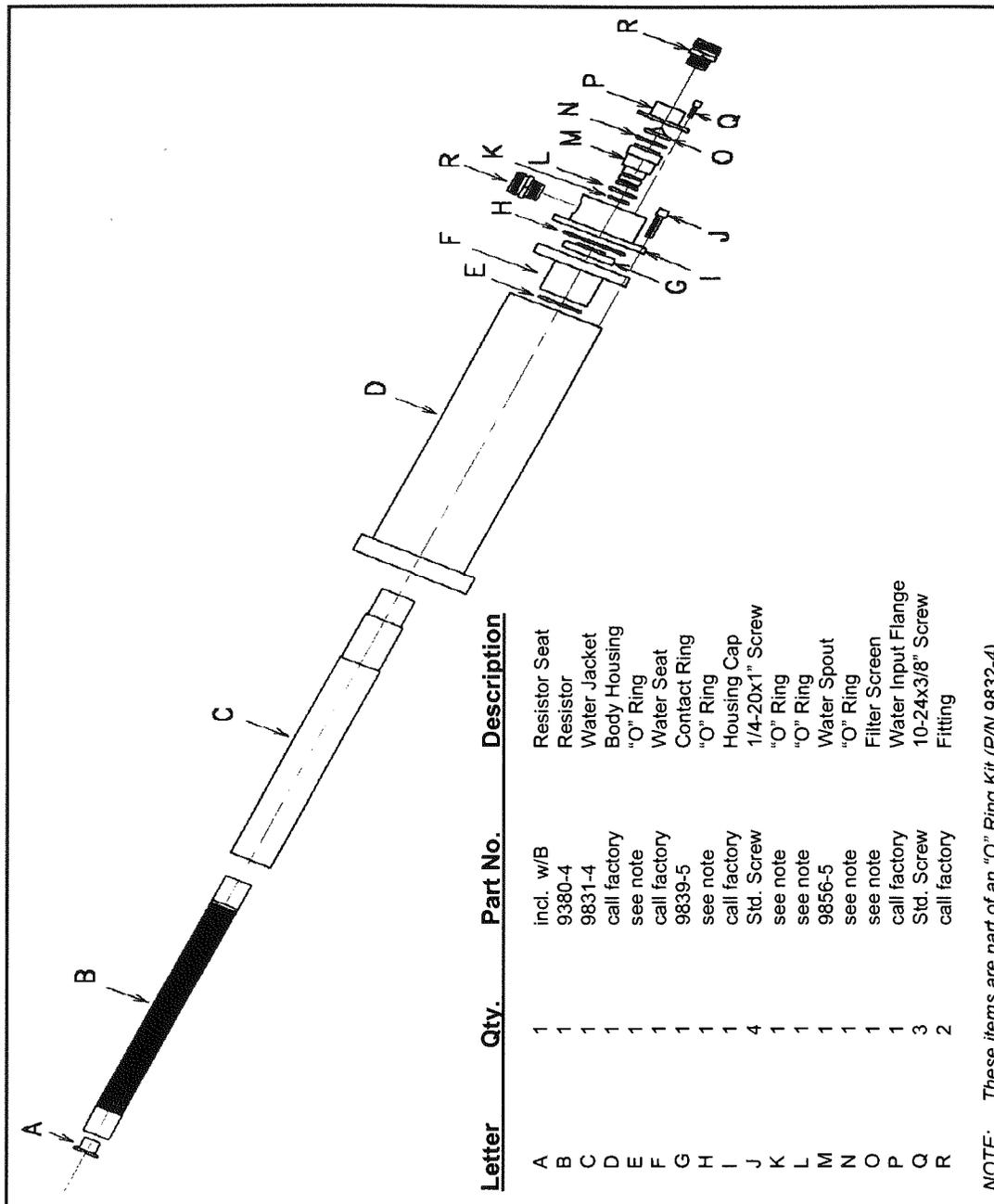


FIGURE 16 - RESISTOR REPLACEMENT FOR 50 KW MODELS

Resistor Replacement - (Refer to Figure 16) To replace the resistor element, remove the three 10-24x3/8" cap screws (item Q). Remove water input assembly (items O, P, and R). Inspect filter screen for damage, replace if eroded or torn. Remove four 1/4-20x1" cap screws (item J). Remove housing cap assembly (items G, H, I, R, K, M and N). Inspect all O-rings for distortion or damage. Replace if pinched, cut, burned or no longer round in cross section. Inspect ring contact (item G) for signs of arcing or loss of silver in the area of contact with the resistor contact band. Replace if damage is noted. If resistor (item B) is not broken, grasp by the end extending from the water seal (item F) and pull it straight out of the load. (If resistor is broken, complete disassembly of load is necessary.) Inspect the silver contact band on the RF input end of the resistor element for signs of arcing or loss of silver as an indication of the condition of the front resistor contact. Visually inspect the inside of the water jacket and front resistor contact for any signs of overheat or damage. Any sign of internal damage indicates further disassembly and repairs are necessary.

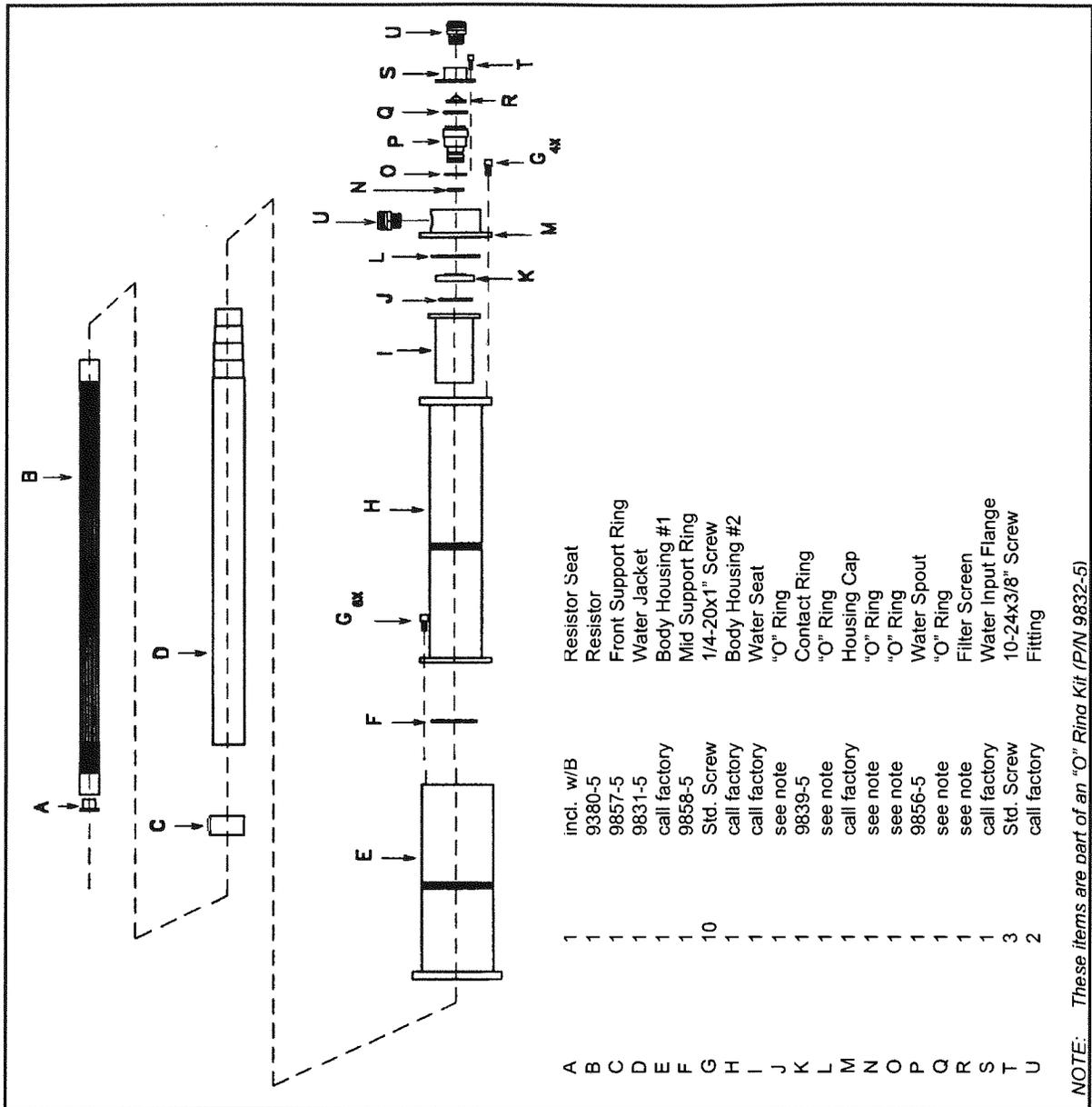


FIGURE 17 - RESISTOR REPLACEMENT FOR 80 kW MODELS

Resistor Replacement - (Refer to Figure 17) To replace the resistor element, remove the three 10-24x3/8" cap screws (item T). Remove water input assembly (items R, S, and U). Inspect filter screen for damage, replace if eroded or torn. Remove four 1/4-20x1/2 socket screws (item G) that secures the housing cap (item M) to the body housing #2 (item H). Remove housing cap assembly (items K, L, M, N, O, P, Q and U). Inspect all O-rings for distortion or damage. Replace if pinched, cut, burned or no longer round in cross section. Inspect ring contact (item K) for signs of arcing or loss of silver in the area of contact with the resistor contact band. Replace if damage is noted. If resistor (item B) is not broken, grasp by the end extending out of the #2 body section (item H) and pull it straight out of the load. (If resistor is broken, further disassembly of load is necessary.) Inspect the silver contact band on the RF input end of the resistor element for signs of arcing or loss of silver as an indication of the condition of the front resistor contact. Visually inspect the inside of the water jacket and front resistor contact for any signs of overheat or damage. Any sign of internal damage indicates further disassembly and repairs. If the resistor is broken, the load body will need to be separated at the joint between the #1 and #2 body sections, (items E and H). This should be done with caution as an internal leak associated with severe failure sometimes causes the air cavity surrounding the water jacket to become filled with coolant. Remove the six 1/4-20 x 1/2" socket head screws (item G) that secures the #2 body section (item H) to the #1 body section (item E). Using a slight twisting motion, pull the two body sections apart. If the load is reasonably clean and corrosion-free and the water jacket is not damaged, this is as far as the load should need to be disassembled for resistor replacement.

