TWO-PHASE REACTION TURBINE

Technical Progress Report
For the Period January-March 2000

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In the prior semi-annual report, for the period of July-December 1999, we have covered extensively the details on how our turbine, housing, and other key components of the heat engine are going to be built. We have also discussed the issue of stresses in the rotor and how we have managed to strengthen it. We have also spent a great effort in looking for a generator and sprocket/chain transmission system that would reduce RPMs from the high-speed turbine rotating at 20,000 rpm to about 6,000 rpm at the electric generator.

The smaller rotor diameter, 8 inches instead of 16 inches, and the smaller housing design has also cut the cost of material and manufacturing about three fold since the total volume is smaller. In the report, we also described our test facility, which is being built at Hercules Boiler Works Company, its capabilities, and the potential applications of our two-phase reaction turbine in various thermal cycles. A complete set of CAD drawings was also included.

In this report, we are going to cover additional details by discussing two more issues of importance: 1) sprocket/chain transmission, and 2) use of 10% steam

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quality brine delivered to the energy conversion part of a geothermal power plant. We will also include, in the attachment section, additional technical details of the assembly parts.

1). Sprocket/Chain Transmission: How Efficient It Is?

There are many things, which we have been doing in order to accomplish as much as possible with limited funds. Just for an example we received two bids estimates of about \$80,000 each for a **dynamometer alone** from the West Coast Research Corp. in Santa Monica, and from Altrudyne in San Diego. For at least two months we worked intensively on designing appropriate dynamometer ourselves. We talked with different people including authors of two books on disc brake. We were designing multi-disc-wet brake dynamometer. We looked into many details such as heat transfer and convection at the critical surfaces, etc. Later on we chose to use an electrical generator with an external electrical load. We are finding interesting and economical solutions in that area as well. One very experienced electrical engineer is helping us.

Similar savings we are getting or trying to get with other components as well. Another example of large savings is avoiding use of regular boiler, which could have cost up to \$80,000. Even initial bid that we got for the high temperature tank plus the heater was at \$16,000 but we will get it for less.

We looked carefully in all kind of transmissions such as coaxial and angular gears various configurations of belts and pulley transmissions, etc. Quotes on gear transmissions were in the range of 18 to 36 thousands of \$, especially for coaxial planetary type. The gear transmissions would be the best but they are way too expensive for our project. We also felt that it would be way too impractical to start to design and build our own gear transmission at this time.

For the sprocket/chain transmission the velocities are important in terms what kind of forces and stresses they will induce due to laws and equations of dynamics. The chain is made of high strength steel with relatively very small elongation. This means that we do not need to use much force to tighten the chain. During the actual running that force would go practically to zero.

The sizes of sprockets to be used are those with diameter PD of 1.44 and 4.777 inches. The chain to be used usually is employed with tensile loads of 925 lbs. (please see enclosed table). The actual yield strength of this chain is 1900 lbs.

Due to rotation of the chain around the small sprocket at 20,000 RPM there are centrifugal forces which will cause tensile forces in the chain of 88 lbs. (We talked to the manufacturer of the chain and sprockets and they calculate these force in the same way we did.) Rotation around the larger sprocket gives about the same forces in the chain. These forces do not add up because they balance each other.

To transfer the power of 25 kW from turbine running at 20,000 RPM an additional tensile force in the chain of 147 lbs. is needed. (This force actually decreases with increasing speed of the chain for design steady state runs parameters.) In this way the maximum force in the chain for steady state running at 20,000 RPM will be 235 lbs. This is considerably lower than the yield strength of 1900 lb.

At lower RPM-s the torque resistance of the generator will be lower. (This is unlike the case in cars.) There are other considerations on how the tests should be run, but it would take way too long to discuss them inhere.

2). Analyze Potential Applications of the FAS Two-Phase Reaction Turbine

In the prior reports we have provided results for a number of configurations of geothermal power plants. In here we will provide also the results for the exact examples suggested by the DOE Geothermal Division Headquarters. These results should be analyzed together with those we have presented earlier. In such a way more extensive information can be drawn upon. The prior cases calculated were based on providing un-flashed zero quality brine to a plant. Those cases indicate that considerably more electrical power can be obtained if pre-flashing of brine can be avoided before it reached the energy conversion part of the plant. In most cases flashing of brine could be avoided by increasing diameter of the upper part of geothermal resource wells or by using down-hole pumps.

In the calculations with results given bellow the efficiency of the steam turbines was assumed to be at 85%. The efficiency of the two-phase flow turbines is assumed to be at 75%. The total incoming brine plus steam flow rate is assumed to be

2.1) Substitution for the throttling valves in a single-flash power plant assuming 335 degF, 110PSIA, about 10% steam quality brine delivered to the plant.

a) Conventional Single Flash Geothermal Plant

Based on additional information and on consideration of heat transfer in a condenser we have assumed condensation temperature for the thermodynamic working fluid to be 25C.

The calculations show that the conventional single flash power plant of the above parameters would produce the electrical power output of 9353kW.

b) Two-Phase Turbines Retrofitted Single Flash Power Plant.

Presently throttled flashing of the initial 0.1 quality geothermal fluid, plus throttling of the separated liquid, can be relatively simply replaced by expansion through two-phase turbines. Calculations show that in that case the total electrical power output of such power plant would be 14,641kW.

This represents improvement of 56.5% over the conventional single flash geothermal power plant.

- 2.2) Substitution for the throttling valves in a dual-flash power plant assuming 335 degF, 110PSIA, about 10% steam quality brine delivered to the plant.
- a) In this case we also took the condensation temperature to be at 25C. The calculations show that the electrical power output of the conventional dual flash power plant would be 12,401kW.
 - b) Retrofitting such a power plant by two-phase turbines in appropriate locations the total electrical power output becomes 14,904kW. This represents an improvement of 20.2% over the conventional dual flash plant.
- 2.3) Trilateral open cycle direct brine power production from the total flow from a geothermal well assuming 335 deg F, 110 PSIA, about 10 % steam quality brine delivered to the plant. (Dry air cooling.) (In this case the energy conversion would be accomplished with only one two-phase flow turbine, with its efficiency assumed to be 75%. There would be no any other steam or vapor turbine.)
- a) If the condensation temperature is 40C then the power output would be 11,920kW,
 - b) If the condensation temperature were 25C then the power output would be 14,344kW.
- 2.4) Trilateral closed cycle binary power plant production using a secondary working fluid assuming saturated liquid brine at 335 degF delivered to the plant. (Dry air cooling.)

In this case we have assumed the temperature difference between the brine and the thermodynamic working fluid to be equal to 5 degC. The condensation temperature was assumed to be 40C. A single two-phase turbine is used with an assumed turbine efficiency of 75%. The thermodynamic working fluid is taken to be octane. Based on the above assumptions the electrical power output would be 7,175kW.

- 2.5) Trilateral open brine cycle power plant assuming saturated brine at 335 degF delivered to the plant. (Dry air cooling)

We have calculated this case as well in order to provide one more comparison. The condensation temperature is 40C. The two-phase turbine efficiency is 75%. Based on these assumptions the electrical power output is 6,705kW.

3). Other Details

In process of ordering parts and instruments and other assembly components, we get a chance to talk to many knowledgeable sale technicians and different companies. Our persistency in looking for the best options to do the right jobs and searching from different resources had given us useful alternatives and choices of solutions that would not only improve and simplify The design but also save the funds. For example, the prices of a product can vary significantly depending on which company you talk to and what product they have. We were able to find a turbine flow meter that costs as low as \$725 while another turbine flow meter of the same specification and accuracy costs at least \$1,500. Another company that was supposed to specialize in valve said that they were not able to find us a solenoid safety shut off valve that operates without air supply. After some research from the internet, we were able to find one. The absence of air supply to operate the valve eliminates the need of an air compressor or bottles and as a result the valve is more compact and simple.

We were very fortunate to have Mr. Hajrudin (Rudy) Mulabecirovic as our electrical engineer expert. He has over 20 years of working experience in this area. He has designed our control system, the resistive load bank for the three phase electric generator, various safety features such as protection from runaway speed of the turbine, protection from excessive electrical currents and voltages. During a discussion session, he advised us to have a safety shut-off control of the turbine to prevent the over speed of the turbine when power failed or when no fluid flows into the turbine. He also advised us on the purchase of electronic instrument for measuring turbine's rpm and all the necessary electrical components that comes with it.

4). Conclusion

At this point, we are glad to have completed all studies and that the prototypes are built and assembled. All schedules were on time as expected and we are pleased that this project has completed beyond our expectation.

Table of Content of Attachment

- 1) CAD drawings of the whole assembly.
- 2) Stresses in rotating disks.
- 3) Forces in roller chain.
- 4) Forces in bearings.
- 5) Labyrinth seal, O-ring spec., turbine's RPM measurement method, and turbine housing spec.

- 6) Turbine flow meter, low level amplifier, and display panel.
- 7) Solenoid safety shut off valve.
- 8) Ball and needle valve.
- 9) Sprockets and chain specification.
- 10) RTD sensor, pressure gauges, and display panel.
- 11) Signal conditioners & transducers: Transmitters and converters.
- 12) Transducers.
- 13) Current & potential transformer.
- 14) Low and high pressure tanks.
- 15) Properties of materials (several tables).

TWO-PHASE TURBINE TEST RIG

TURBINE-GENERATOR SCHEMATIC DIAGRAM

PART NAMES

PART NAMES

FLOOR PLAN FOR FAS TWO-PHASE TURBINE TEST

P2

Horizontal Dimension

Cross-Section B-B

Thread size = 1.125 in.
 12 threads per inch
 Minor Diameter = 1.0258 in.
 Pitch Diameter = 1.0709 in.

P2

Vertical
Dimension

Key Dimension

P2

Tightening Bolt for the Rotor

Thread size = 1.125 in.

12 threads per inch

Minor Diameter = 1.0348 in.

Pitch Diameter = 1.0709 in.

P3

Vertical Dimension

Horizontal Dimension

Rotor, Top View

Rotor Top View

Bolt Position Table

Position	Angle(degree)	Radius(inch)
1	157	0.8
2	57	0.8
3	85	1.35
4	120	1.83
5	152	2.25
6	182	2.74
7	200	3.06
8	220	3.35
9	9	1.35
10	52	1.83
11	101	2.40
12	138	2.98
13	165	3.42
14	182	3.77
15	198	4.04

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Dimensions in Inches

Angle	Radius	Alpha	A	B	X	Y	A/Cos(Alpha)
12.032	0.670	60.846	0.394	0.550	0.659	0.140	0.809
22.918	0.866	46.696	0.394	0.435	0.798	0.337	0.574
34.378	1.035	37.815	0.315	0.347	0.855	0.585	0.399
45.837	1.189	32.315	0.275	0.275	0.828	0.853	0.325
48.702	1.228	31.284	0.275	0.275	0.811	0.923	0.322
51.566	1.264	30.424	0.275	0.275	0.786	0.990	0.319
57.296	1.342	28.992	0.275	0.298	0.725	1.130	0.314
68.755	1.492	27.216	0.275	0.340	0.541	1.391	0.310
80.214	1.645	25.669	0.275	0.382	0.280	1.622	0.305
91.674	1.803	24.294	0.283	0.413	-0.053	1.802	0.310
114.592	2.146	21.887	0.295	0.491	-0.893	1.951	0.318
137.510	2.500	19.996	0.315	0.559	-1.844	1.689	0.335
160.429	2.870	18.449	0.335	0.627	-2.704	0.961	0.353
183.347	3.260	17.132	0.354	0.689	-3.254	-0.190	0.370
206.266	3.673	15.986	0.394	0.840	-3.294	-1.626	0.410
226.319	4.000	15.126	0.433	0.879	-2.763	-2.892	0.448
229.319	4.057	15.126	0.439	0.885	-2.644	-3.077	0.455
232.319	4.114	15.126	0.445	0.891	-2.515	-3.256	0.461
235.319	4.172	15.126	0.451	0.897	-2.374	-3.431	0.467
238.319	4.231	15.126	0.457	0.903	-2.222	-3.600	0.473
241.319	4.291	15.126	0.463	0.909	-2.059	-3.764	0.480
244.319	4.352	15.126	0.469	0.915	-1.886	-3.922	0.486
247.319	4.413	15.126	0.475	0.921	-1.702	-4.072	0.492
250.319	4.475	15.126	0.481	0.927	-1.507	-4.214	0.500

Flow Discharge

Cross-Sectional View E-E

P4

Horizontal Dimension

O-ring Spec.

Seal Science, Inc. (714) 957-1007

ID=1.114 $\pm$ 0.010

OD(Mean)=1.254

Width=0.070 $\pm$ 0.003

Insert Piece # 1

Insert Piece # 2

Labyrinth Seal Dimension

P4

Vertical Dimension

P5

Vertical Dimension

Horizontal Dimension

P6

Vertical Dimension

Horizontal Dimension

P7

T-Beam Support

Cross Section A-A

Support Pieces

P8

Vertical Dimension

Horizontal Dimension

P9

Vertical Dimension

Horizontal Dimension

90 Degree Elbow

P10

Shield Box Top View

Shield Box Side View

P11

Generator Support Top View

Generator Support Side View

Stresses in Rotating Disks

In high speed rotating disks such as those used in steam and gas turbines, the major stresses of concern are due to centrifugal forces acting on the rotating disks. The stresses due to tangential forces are usually small.

For a solid thin disk of radius "b" and constant thickness, the maximum stress occurs at the center of the disk and is given by:

$$\sigma_r = \sigma_\theta = \frac{3 + \nu}{8} \cdot \rho \cdot \omega^2 \cdot b^2 \quad \text{—————(1)}$$

If the disk has a circular hole of radius "a" at the center, the maximum stress occurs at the inner boundary and is given by:

$$\sigma_\theta = \frac{3 + \nu}{4} \cdot \rho \cdot \omega^2 \cdot b^2 \cdot \left[1 + \frac{1 - \nu}{3 + \nu} \cdot \left(\frac{a^2}{b^2} \right) \right] \quad \text{—————(2)}$$

So, if the circular hole is very small, the ratio (a/b) becomes negligible and the maximum stress in equation (2) becomes:

$$\sigma_\theta = \frac{3 + \nu}{4} \cdot \rho \cdot \omega^2 \cdot b^2 \quad \text{—————(3)}$$

This shows that if we make a small circular hole in a rotating disk (no matter how small the hole may be), the stress is doubled.

Stresses in Rotating Cylinders (or Shafts)

For a rotating long circular shaft or cylinder:

The maximum stress for the solid shaft occurs at its center and is given by:

$$\sigma_r = \sigma_\theta = \frac{1}{8} \cdot \frac{3 - 2 \cdot \nu}{1 - \nu} \cdot (\rho \cdot \omega^2 \cdot b^2) \quad \text{—————(4)}$$

The maximum stress for the hollow shaft with inner and outer radii "a" and "b" occurs at the inner surface and is given by:

$$\sigma_\theta = \frac{1}{4} \cdot \frac{3 - 2 \cdot \nu}{1 - \nu} \cdot (\rho \cdot \omega^2 \cdot b^2) \cdot \left[1 + \frac{1 - 2 \cdot \nu}{3 - 2 \cdot \nu} \cdot \left(\frac{a^2}{b^2} \right) \right] \quad \text{—————(5)}$$

Here, we see again that if the ratio (a/b) is negligible, the maximum stress is doubled when a solid shaft has a small hole drilled through its center.

References: Wang, Chi-Teh. Applied Elasticity. McGraw-Hill Book Company, New York. 1953.

Sample Calculation:

Disk with circular hole

$$\nu = 0.3 \quad \rho = 7800 \frac{\text{kg}}{\text{m}^3} \quad \omega = 2000 \frac{\text{rad}}{\text{s}}$$

$$a = \frac{0.031}{2} \text{ m (1.21" Diameter)} \quad b = \frac{0.216}{2} \text{ m (8.5" Diameter)}$$

$$\sigma_{\theta} = \frac{3+\nu}{4} \cdot \rho \cdot \omega^2 \cdot b^2 \cdot \left[1 + \frac{1-\nu}{3+\nu} \cdot \left(\frac{a^2}{b^2} \right) \right]$$

$$\sigma_{\theta} = 3.015 \cdot 10^8 \frac{\text{N}}{\text{m}^2} \quad 2714 \text{ MPa}$$

Shaft with circular hole

$$\nu = 0.3 \quad \rho = 7800 \frac{\text{kg}}{\text{m}^3} \quad \omega = 2000 \frac{\text{rad}}{\text{s}}$$

$$a = \frac{0.016}{2} \text{ m (0.63" Diameter)} \quad b = \frac{0.031}{2} \text{ m (1.21" Diameter)}$$

$$\sigma_{\theta} = \frac{1}{4} \cdot \frac{3-2\nu}{1-\nu} \cdot (\rho \cdot \omega^2 \cdot b^2) \cdot \left[1 + \frac{1-2\nu}{3-2\nu} \cdot \left(\frac{a^2}{b^2} \right) \right]$$

$$\sigma_{\theta} = 6.71 \cdot 10^6 \frac{\text{N}}{\text{m}^2} \quad 60 \text{ MPa}$$

Forces in roller chain

Sprockets, 0.250 Pitch

#1: O.D. = 1.44", 19 teeth

#2: O.D. = 4.77", 48 teeth

The ratio of 4.77 to 1.44 is 3.3, this would reduce
20,000 rpm to about 6037 rpm

Roller Chain, 0.250 Pitch

Material: Hardened Steel

Average Tensile Load: 925 lbs.

Average Weight Per ft.: 0.09 lbs

There are two forces of concern acting on the roller chain when the shaft rotates at high speed. First of all is the force due to centripetal acceleration acting on the roller chain as it turns around the corner. The angle of turn occurs from 0 to 180 degree (on the circumference of the sprocket) at both ends of the sprockets. The second force, which is the bigger one, is the force needed to transfer power.

$$\text{Average weight per foot of the hardened steel is } 0.09 \frac{\text{lbm}}{\text{ft}} = 0.09 \frac{\text{lbm}}{\text{ft}} \cdot \frac{1 \text{ kg}}{2.2046 \text{ lbm}} \cdot \frac{1 \text{ ft}}{0.3048 \text{ m}} = 0.13394 \frac{\text{kg}}{\text{m}}$$

$$\omega := \frac{20000 \cdot 2 \cdot \pi}{60}$$

$$\omega = 2.094 \cdot 10^3 \frac{\text{rad}}{\text{s}}$$

$$r := \frac{1.440}{2} \cdot 0.0254 \quad (\text{radius of small sprocket})$$

$$r = 0.018 \text{ m}$$

$$a := r \cdot \omega^2$$

$$a = 8.022 \cdot 10^4 \frac{\text{m}}{\text{s}^2}$$

$$L := 0.01 \text{ m} \quad \text{A fractional length of the chain}$$

$$\Delta m := 0.13394 \cdot L$$

$$\Delta m = 0.001 \frac{\text{kg}}{\text{cm}}$$

A fractional mass of the chain

$$\Delta F := \Delta m \cdot a$$

$$\Delta F = 107.447 \frac{\text{N}}{\text{cm}}$$

A fractional force of the chain

Equivalent Pressure Force

$D = 2 \cdot r \cdot 100$ Diameter of the sprocket

$$D = 3.658 \text{ cm}$$

$$F_{\text{equivalent}} = \Delta F \cdot D$$

$$F_{\text{equivalent}} = 392.998 \text{ N}$$

$$\frac{F_{\text{equivalent}}}{4.448} = 88.354 \text{ lb} \quad \text{This is the force exerted by the sprocket due to centripetal acceleration}$$

Chain Force to Transfer Power

$$\text{Power} = \text{Torque} \cdot \Omega \quad \text{Power} = 25000 \text{ W}$$

$$\tau = \frac{\text{Power}}{\omega}$$

$$\tau = 11.937 \text{ N}\cdot\text{m}$$

$$\text{Chain force is: } F_{\text{chain}} = \frac{\tau}{r}$$

$$F_{\text{chain}} = 652.702 \text{ N}$$

$$\frac{F_{\text{chain}}}{4.448} = 146.741 \text{ lb}$$

$$\text{Force}_{\text{total}} = \frac{F_{\text{equivalent}} + F_{\text{chain}}}{4.448}$$

$$\text{Force}_{\text{total}} = 235.094 \text{ lb}$$

Bearing Forces

Bearing information are as follows:

Single Row Radial Ball Bearing: O.D.=1.8504", I.D.=0.9843", width=0.4724"

Basic Load Ratings: Dynamic=1740 lbs, Static=1160 lbs

Axial Thrust = 30% of Static Load = 1160 lbs X 0.3 = 348 lbs

Mass of Rotor

$$\text{volume} = \text{Area} \cdot \text{Thickness} = \pi r^2 \cdot t \quad r := \frac{8.5}{2 \cdot 12} \text{ ft} \quad t := \frac{1.3}{12} \text{ ft} \quad \pi = 3.142$$

$$\text{Volume}_{\text{rotor}} := \pi r^2 \cdot t$$

$$\text{Volume}_{\text{rotor}} = 0.043 \text{ ft}^3$$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad \text{Mass} = \text{Density} \cdot \text{Volume}$$

$$\rho := 489 \frac{\text{lb}}{\text{ft}^3}$$

$$\text{Mass}_{\text{rotor}} := \rho \cdot \text{Volume}_{\text{rotor}}$$

$$\text{Mass}_{\text{rotor}} = 20.875 \text{ lb}$$

Mass of Shaft

$$r := \frac{0.98}{2 \cdot 12} \text{ ft} \quad t := \frac{13.6}{12} \text{ ft}$$

$$\text{Volume}_{\text{shaft}} := \pi r^2 \cdot t$$

$$\text{Volume}_{\text{shaft}} = 0.006 \text{ ft}^3$$

$$\text{Mass}_{\text{shaft}} := \rho \cdot \text{Volume}_{\text{shaft}}$$

$$\text{Mass}_{\text{shaft}} = 2.903 \text{ lb}$$

Total Mass of Shaft and Rotor

$$\text{Mass}_{\text{rotorshaft}} = \text{Mass}_{\text{rotor}} + \text{Mass}_{\text{shaft}}$$

$$\text{Mass}_{\text{rotorshaft}} = 23.778 \text{ lb}$$

Axial Force Exerted by the High Pressure Fluid

$$\text{Pressure}_{\text{fluid}} = \frac{\text{Force}_{\text{fluid}}}{\text{Area}_{\text{contact}}}$$

$$r_1 = \frac{0.63}{2} \text{ in} \quad r_2 = \frac{0.98}{2} \text{ in}$$

$$\text{Area}_{\text{contact}} = \pi r_2^2 - \pi r_1^2 \quad \text{Pressure}_{\text{fluid}} = 350 \text{ psi}$$

$$\text{Force}_{\text{fluid}} = \text{Pressure}_{\text{fluid}} \cdot \text{Area}_{\text{contact}}$$

$$\text{Force}_{\text{fluid}} = 154.9 \text{ lb}$$

Since the force exerted by the fluid, 155 lbs, is greater than the total mass of the rotor and shaft, 24 lbs. The net force is $155 - 24 = 131$ lbs which is still smaller than the maximum allowable thrust the bearing can take, which is 348 lbs.

Labyrinth Seal

The number of teeth on the labyrinth seal is determined by making sure that the inlet pressure of 250 psi is to be reduced to 1 psi at the end of the teeth. This is to ensure minimal leakage occurs between the labyrinth seal and the shaft. The pressure drop between each teeth is estimated to be half the previous pressure according to "the converging-diverging duct throat for choked flow" in fluid mechanics. Additionally, we also inject a pressurized steam into the labyrinth seal to block off steam leakage coming from the entrance.

O-ring specification

I.D.=1.114"
O.D.=1.254"
Width=0.070"

Turbine's RPM measurement

We use an optical tachometer to measure the rpm of the turbine. At the end of the shaft, we will have a thin circular piece of aluminium plate, about 2" in diameter, attached to the shaft by a set screw. The surface of the thin plate will then be painted half black and half white so that the optical tachometer can count the number of rpms based on reflection from the plate. It is important to note that the distance between the tachometer and the thin plate is close enough so that the meter is reading reflection from the plate rather than from the surroundings.

Turbine Housing

Below is a material list and their specifications that we ordered from Tell Steel for the assembly of our turbine housing.

- H1). One 13.5" O.D., 1-3/4" thick HR A-36 Plate.
- H2). One 13.5" O.D., 8.0" I.D., 1/2" thick HR A-36 Plate.
- H3). One 19.0" O.D., 9.0" I.D., 1/2" thick HR A-36 Plate.
- H4). One 4-1/8" height, 60.0" long, 1/2" thick HR A-36 Plate.
- H5). Three 25.0" O.D., 18.0" I.D., 1/2" thick HR A-36 Plate.
- H6). One 25.0" O.D., 3/4" thick HR A-36 Plate.
- H7). One 6.25" height, 60.0" long, 1/2" thick HR A-36 Plate.
- H8). One 7-3/8" O.D., 1/2" thick HR A-36 Plate.
- H9). One 5.0" O.D., 1/2" thick HR A-36 Plate.
- K). One 1/2" thick, 12" height, 30" long HR flat plate.
- L). Two 11.0" O.D., 8.0" I.D., 1/2" thick HR A-36 Plate.
- N). One 1/4" thick, 12" height, 12" long HR A-36 Plate.
- O). One 1/2" thick, 1-1/2" height, 18" long HR flat plate.
- P). One 1/4" thick, 4-1/2" height, 8" long HR flat plate.

TURBINE-GENERATOR SCHEMATIC DIAGRAM

LOW LEVEL AMPLIFIER

NEW

2000 USA

Model FLSC-AMP

\$66

Basic Model

- ✓ Ultra-Low-Speed to 15 kHz Operation
- ✓ 20 mV to 50 V Sensitivity
- ✓ 100 mA Current Sinking Output
- ✓ 11 to 26 Vdc Power Supply Range
- ✓ Easy Mount Metal Housing
- ✓ Screw Terminal Hookup

The OMEGA® FLSC-AMP amplifies the low level signals from the magnetic pickup of gear teeth or flow transmitters by a factor of more than a hundred times to drive any OMEGA® ratemeter, counter or controller. It is mounted in a rugged 2 x 3" metal housing with screw terminals for easy installation.

SPECIFICATIONS

Power Requirements:

11 to 26 Vdc; 30 mA maximum.

Input Characteristics:

Input Impedance: 1500 ohms.

Input Frequency: 0-15 kHz.

Input Voltage: 0.020 to 50 V

Output Characteristics:

Open Collector with internal 2700 ohms pull-up resistor to supply voltage.

100 mA maximum sink to 1 v or less

Temperature Range:

32 to 140°F (0 to 60°C).

NOTE: The low voltage line from the magnetic pickup to the FLSC-AMP should be less than 3 m (10 ft.) in length, shielded and isolated from relays, solenoids or other sources of electrical noise (let the output line make the long run). If the input is too sensitive, lower the 1.1K input impedance by adding a 220 to 1 Kohm resistor across TB1, pins 1 and 2, to increase noise immunity.

To Order (Specify Model Number)		
Model No.	Price	Compatible Sensors
FLSC-AMP	\$66	FTB-100/900/930/950 FTB-5100/5200/5300 FP-6000

ECONOMICAL BALL BEARING LIQUID TURBINE FLOWMETERS with Male NPT Ports

NEW

\$725

Basic Unit
without Signal
Conditioner

- ✓ $\pm 1\frac{1}{2}\%$ of Reading Accuracy
- ✓ Ball Bearing Design for Economy
- ✓ 440C Bearing Retainers for Durability
- ✓ Ball Bearings Field Replaceable Without Loss of Calibration
- ✓ Deflector Cones Stabilize the Low Mass Rotor for Increased Bearing Life
- ✓ NIST Certificate Supplied Standard

FTB-909 Turbine
Shown with
FLSC-61 Signal
Conditioner

The OMEGA® FTB-900 Series Turbine Meters have male NPT end fittings for easy connections. These units are supplied with a mating 2-wire connector and can be supplied with the integrally mounted signal conditioners FLSC-60 Series to provide 4-20 mA, 0-5 Vdc, or amplified pulse outputs.

These turbine meters are intended for clean fluid service only; where there is any doubt, strainers are recommended. In addition, when using these units for fluids with

viscosities other than 1 centistoke, special calibrations and universal viscosity curves are available — consult Flow Engineering Department.

SPECIFICATIONS:

Accuracy: $\pm \frac{1}{2}\%$ of reading
Repeatability: $\pm 0.05\%$
Materials of Construction:
Body: 304 stainless steel;
Rotor: 17-4 pH SS

Bearings: 440C stainless steel
Output: 30mV p-p sinewave minimum
Electrical: Two-wire connector included
Maximum Pressure Drop: 4 psid

To Order (Specify Model No.)

Model No.	Price	Linear Range Water (GPM)	Rated Nominal K-Factors	Maximum Operating Pressure (PSI)	Overall Length	End Connections MNPT	Approx. Wt. (oz.)
FTB-901	\$725	.5 - 2.5	15,000	5,000	3"	$\frac{1}{2}$ "	6
FTB-902	725	.75 - 5	6,000	5,000	3"	$\frac{1}{2}$ "	6
FTB-903	725	1.25 - 9.5	3,160	5,000	3"	$\frac{1}{2}$ "	6
FTB-904	725	1.75 - 16	1,875	5,000	3"	$\frac{1}{2}$ "	12
FTB-905	725	2.5 - 29	1,035	5,000	3 $\frac{1}{4}$ "	$\frac{3}{4}$ "	12
FTB-906	750	4 - 60	500	4,000	3 $\frac{1}{2}$ "	1"	22
FTB-907	775	6 - 93	322	3,000	3 $\frac{7}{8}$ "	1 $\frac{1}{4}$ "	28
FTB-908	850	8 - 130	230	2,000	4 $\frac{3}{8}$ "	1 $\frac{1}{2}$ "	37
FTB-909	950	15 - 225	133	1,500	4 $\frac{3}{4}$ "	2"	48
FTB-910	995	25 - 400	75	1,500	6 $\frac{1}{16}$ "	2 $\frac{1}{2}$ "	55
FTB-911	1,275	40 - 650	46.1	1,000	10"	3"	160

Ordering Example: To order a scaled system which includes: Signal Conditioner, Turbine Meter with MNPT End Fittings, Specify Model Number: SYS/FTB-901/FLSC-61, \$1,000.

DPF70 SERIES RATEMETERS, TOTALIZERS, AND BATCH CONTROLLERS

For Amplified Frequency Inputs

1 YEAR
WARRANTY

MADE IN
USA

Shown Larger Than
Actual Size

The DPF75 is a combination 6 digit totalizer/batch controller and 5 1/2 digit ratemeter with two relays for 2-stage batch control or dual rate alarms. One relay can be set for batch and the other set for rate alarm, if desired. The totalizer and ratemeter display in the same engineering units, the ratemeter displaying in units per second, minute, or hour. The DPF75 can accept two inputs and separately scale them for "A-B" or "A+B" with display and relay control of the net total in engineering units. Either input A rate or net total can be displayed.

The DPF76 is a 6 digit scalable totalizer/batch controller ONLY with two relays for 2-stage batch control. The DPF78 is a 4 1/2 digit scalable ratemeter ONLY with two alarm relays. The optional analog output is proportional to rate or total on the DPF75.

SPECIFICATIONS

Input Power: 110 Vac or $\pm 15\%$ or 11 to 15 Vdc; 220 Vac $\pm 15\%$ or 11 to 15 Vdc. Max. current = 250 mA DC or 32 VA at rated AC voltage

Output Power: (AC powered units only) + 12 Vdc @ 50 MA, unregulated $\pm 25\%$

Rate Accuracy: $\pm 0.01\%$ of reading ± 1 LSD

K Factor: up to 5 digits

Temperature: Operating: $+32^\circ\text{F}$ to $+130^\circ\text{F}$; Storage: -40°F to 200°F

Memory: EEPROM stores data for 10 years if power lost

Pulse Input: Low = 0-1 Vdc; High = 4-30 Vdc; 10 Kohm impedance; up to 10 KHz.; min. 0.05 Hz for rate indication.

Relays: Rated 10 Amps @ 240 Vac or 28 Vdc. SPST, solder jumper selectable for N.O. or N.C., relays latch or autorecycle after 0.1 to 99.9 seconds.

Panel Cutout: 1.772" H x 3.622" W (DIN standard); 4.06" depth.

Shipping Weight: 2 lbs

To amplify low-level turbine and paddlewheel sensor inputs, order amplifier model number FLSC-AMP. Price \$65

To Order (Specify Model Number)

**HIGHLIGHTED MODELS STOCKED
FOR FAST DELIVERY**

Model No.	Price	Description
DPF75	\$265	Ratemeter and batch controller with 2 separate 5A SPDT relays for rate alarm or batching
DPF76	\$227	Scalable totalizer/batch controller with relays
DPF78	\$227	Scalable ratemeter with 2 separate 5A SPDT alarms
Optional Accessory		
FLSC-AMP	\$65	Amplifies low-level turbine and paddlewheel sensor inputs

For 220 Vac power, add suffix "220 Vac" to part number No charge. For RS-232 or RS-422 output, add suffix "RS232" or "RS-422" and add \$122 to price. Example: DPF75-RS232 is a ratemeter/batch controller with RS-232 output. Price: \$387 For field-selectable 4-20 or 0-20 mA output, add suffix "A" to part number, and add \$115 to price (Not available on DPF76)

Valve Selection Chart

Valve Selection Chart

Max. Temp		212 F				400 F			
Construction		Bronze						Stainless Steel	
Valve Type		<u>D</u>	<u>G</u>	<u>N</u>	<u>A</u>	<u>M</u>	<u>S</u>	<u>L</u>	<u>K</u> <u>W</u>
Max. Diff. Pressure		30#	35#	300#	500#	150#	180#	500#	500# 180#
Pipe Size, In.		3/8 - 2	1 - 3	1/4 - 3/4	1/2 - 3	3/8 - 3/4	1/2 - 3	1/2 - 3	1/2 - 1 1/2 - 1
Full Port		Y	Y	N	Y	N	Y	Y	Y Y
Fluids	Air	Y	Y	Y	Y	Y	N	Y	Y N
	Brine	N	N	Y	Y	Y	N	Y	Y N
	Gas	Y	Y	N	Y	N	N	Y	Y N
	Oil	N	N	Y	Y	Y	N	Y	Y N
	Solvents	N	Y	Y	Y	Y	N	Y	Y N
	Water	N	Y	Y	Y	Y	N	Y	Y N
	Vacuum	Y	Y	Y	Y	N	N	N	N N
	Steam	N	N	N	N	Y	Y	N	N Y
	Cryogenic	N	N	N	N	Y	N	Y	Y N
	Oxygen	N	N	N	N	Y	N	Y	Y N
	Corrosive	N	N	N	N	N	N	N	Y N

FOR FLUIDS NOT LISTED ABOVE AND FOR SPECIAL APPLICATIONS CONSULT OUR ENGINEERING STAFF

The Valve Selection Chart is to be used as a guide to determine suitable types of Magnatrol valves for a given application. It will be found, for example, that for a 1/2 in. valve for use on 100 psi steam, there are two types suitable and the final selection can only be made after referring to Type M and S valve tables.

**THIS SITE ONLY SHOWS OUR NORMALLY CLOSED VALVES.
CONTACT US OR YOUR RESELLER FOR NORMALLY OPEN VALVES
WHICH ARE AVAILABLE FOR COMPARABLE PRESSURE RATINGS IN ALL VALVE
TYPES (EXCEPT TYPE "D").**

Normally open valves are indicated by an R after the type letter.

Example: 18A42 = Normally closed 18AR42 = Normally open

Bronze valves can be furnished electroless nickel plated. All wetted parts are stainless steel or nickel plated with valve discs furnished with proper material for service intended. Can be used where fluid is injurious to bronze.

Application Notes

1. Solenoid valves will control the flow in one direction only, as indicated by arrow cast on valve body.
2. Valves must be installed in horizontal pipe with solenoid vertical and on top.
3. The maximum differential pressure is the maximum difference between pressure on the upstream side and the downstream side of a valve at which the solenoid valve will operate.

When you order be sure to specify

- Pipe Size
- Type
- Voltage (AC or DC)
- Hertz
- Fluid
- Fluid Temperature
- Max. Diff. Press.
- Optional Features

Strainers are recommended for use with solenoid valves

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Magnatrol Valve Corporation
P.O. Box 17 | Hawthorne, NJ 07507 | U.S.A.
Phone 973-427-4341 | Fax 973-427-7611
info@magnatrol.com

Solenoid Coils

Easily Accessible

Unsurpassed ease of access is provided on all Magnatrol Valves as the entire solenoid and piston assembly can be removed without breaking flexible electrical connection and while valve body remains in pipe line. Periodic inspection, cleaning or servicing can be readily performed. Valve shown is typical of Type A, 1/2 in. through 1-1/4 in.

Magnatrol Solenoid Coil

Electrical Characteristics

Coils are stocked for the following voltages:

VOLTAGE	6	12	24	32	48	64	120	208	240	480	575
50, 60 Hertz AC			●				●	●	●	●	●
DC	●	●	●	●	●	●	*		*		

* Furnished with surge protecting capacitor

Reference should be made to the bronze and stainless steel valve type tables to determine the availability of a required valve for a specific power supply.

Consult the factory for information regarding voltage and frequencies not listed.

Valves for AC service can be converted for use on other AC voltages simply by changing the coil. Similarly DC valves can be converted for other DC voltages. Consult factory regarding conversion from AC to DC or DC to AC.

Current Consumption

Current values shown in the bulletins are for 120 volts, 60 hertz. For other voltages the current is inversely proportional; for instance, if a given valve draws 0.5 amperes on 120 volts it would draw 0.25 amperes on 240 volts, or 0.125 amperes on 480 volts. Where power consumption is shown in DC watts, the values given should be divided by line voltage to obtain the current in amperes. Power consumption for all valves is shown in the bronze and stainless steel valve type tables.

Construction

All coils can be energized continuously without overheating or failure. Eighteen inch leads are standard. Coils are encapsulated with the correct compound for temperature service intended, which produces a coil which has excellent resistance to shock, moisture, oil, and chemicals. Coils are available in two basic constructions depending on service.

General Service: Class A coils are supplied in all valves for gases and liquids up to 212 deg. F, and where ambient temperatures do not exceed 40 deg. C (104 deg. F). The class H coil should be specified for higher ambient temperatures.

High Temperature Service: Class H coils are supplied in all valves for gases and liquids from 212-400 deg. F, and where ambient temperatures do not exceed 100 deg. C (212 deg. F).

Installation

The coil is a two wire device which may be controlled by either a single or double pole switch. The switch should always be installed in the hot leg of 120 volt circuits. Where both legs are hot, such as 240 or 480 volt circuits, a double pole switch is preferable, however, if a single pole switch is used, then the wiring should have top quality insulation since even minute leakage currents may give rise to sticking problems. On motor hookup with step control starter full voltage should be supplied to coil immediately. Coil can be readily changed while valve is still under pressure.

Check the bronze and stainless steel valve type tables for listed valves.

Valve Construction Features

MAGNATROL SOLENOID OPERATED VALVES are used to control the flow of liquids or gases, generally in conjunction with automatic control apparatus such as thermostat, float switch, time switch, or flow meter.

* Valve shown is typical of Type A - Normally Closed, 1/2 in. through 1-1/4 in.

Housing

Made of malleable iron, designed for rugged industrial use, the housing protects the coil from accidental damage. All solenoid housings feature a self-contained terminal box with 1/2 in. tapped conduit connection which may be turned in various directions for convenient wiring.

Piston Assembly

A sturdily constructed stem assembly consisting of a laminated plunger and stainless steel pilot flexibly connected to the piston. The discs are of standard sizes with material as dictated by operating conditions.

Coil

Coils are available with class A or H insulation and are designed for continuous duty.

Bonnet

A flanged metallic tube encloses the plunger and hermetically seals the top of the valve.

Valve Body

Constructed of high pressure cast bronze or stainless steel in a globe pattern with screwed ends. Available in a full range of sizes.

Valve Construction Features

- 2-Way globe design
- Bronze or stainless steel body with female threads
- Full port-internal pilot operated or direct acting
- Packless construction
- Continuous duty coils for all voltages
- No differential pressure required to open.

Strainers

Application:

The presence of foreign particles in an automatic valve may seriously affect its dependability. The installation of a strainer close to the inlet side of valve is the best means of preventing entrance of pipe chips, scale, or sediment into valve, provided the screen is periodically removed for cleaning.

Construction

Strainer bodies have screwed ends. Screens are of stainless steel with opening sizes as listed in table. Other sizes can be furnished upon request. Liberal straining area provides for fluid passage at minimum pressure drop. Screens are easily removed for cleaning. Strainers are furnished with NTP blowoff connections unplugged. See chart below for blow-off sizes.

Pressure-Temperature Ratings

MATERIAL	STEAM	LIQUIDS
Bronze	300 psi@ 450°F	600 psi@ 100°F
Stainless Steel	845 psi@ 750°F	1440 psi@ 100°F

BRONZE STRAINERS

Pipe Size, In.	Screen Size	Type No.	Shipping Weight, lbs.	Dimensions, In.		
				A	B	C
1/4	60 Mesh 0.009 Openings	ST 0	1	2-3/4	1-7/8	1/4
3/8		ST 1	1	2-3/4	1-7/8	1/4
1/2		ST 2	1-1/2	3-1/2	2-1/8	1/4
3/4		ST 3	2-1/4	3-7/8	2-1/2	1/4
1		ST 4	3-1/4	4-5/8	3	1/2
1-1/4	0.020 Dia. Perforations	ST 5	5-1/2	5-1/8	3-3/4	1/2
1-1/2		ST 6	6-3/4	6	4-3/8	3/4
2		ST 7	11-1/2	6-7/8	5-1/2	1
2-1/2		ST 8	16	8-3/8	6-1/2	1-1/4
3		ST 9	34	12-1/8	7-1/2	1-1/2

STAINLESS STEEL STRAINERS

Pipe Size, In.	Screen Size	Type No.	Shipping Weight, lbs.	Dimensions, In.		
				A	B	C
1/2	60 Mesh 0.009 Openings	ST 2SS	1-1/2	3	2-3/8	1/4
3/4		ST 3SS	2-1/4	3-3/4	2-13/16	3/8
1		ST 4SS	3-1/4	4-5/8	3-1/8	3/8

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 Webmaster: [BRT](#)

Optional Features

Explosion-Proof and Watertight Solenoids

(designated by prefix F) can be furnished on valves to be installed in hazardous or wet locations (NEMA4, 7C and D, 9E, F and G). Internal construction, pressure ratings, power consumption, and external dimensions are the same as for standard valves. See individual bulletins for availability and additional cost.

BOTTOM MOUNTED OPTIONS

Note: Only one of the following six options can be installed on each valve.

Manual Override

(designated by prefix MO) provides for manual opening of solenoid valve in order to override an automatic control or in the event of a power failure.

Available for all valve types.

Lever

(designated by prefix LV) provides for rapid manual opening of valve. Can be chain operated and is well suited for emergency use at inaccessible locations.

Available - Types: A, S, L, G

Dashpot

(designated by prefix DP) can be furnished for use with clean liquids to delay the closing slightly thereby reducing water hammer effect sometimes encountered on longer runs of pipe.

Available - Types: A,L

Flow Control

(designated by prefix FC) provides a manual method of reducing or throttling the flow. Consult factory regarding application.

Available - Types: M,N,A,S,L

Mounting Stud

(designated by prefix MS) with 3/8-16 thread can be furnished in bottom of body to facilitate mounting on bracket. (Not available on 2-2 1/2-3.)

Available - Types: M,N,A,S,L,D,G

Drain

(designated by prefix DR) 1/4" NPT plug supplied in bottom of valve to facilitate draining of liquid from valve body.

Available - Types: M,N,A,S,L,D,G

OTHER OPTIONS

Pilot Tap

(designated by prefix PT) - 1/8" tapped hole for pilot connection or pressure guage.

Available - Types: D,G

How to Indicate Optional Features When Ordering

Preface the type number as selected in the bronze and stainless steel valve type tables with the letter or letters that indicate the option or options required.

Example: F 18A44

Indicates an Explosion Proof type 18A44 valve.

Example: MO 18A44

Indicates Manual Override on a type 18A44 valve.

Example: MOF18A44

Indicates Manual Override on an Explosion Proof type 18A44 valve.

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Webmaster: [BRT](#)

SPECIFICATION SHEET

Precision Valve Products

A DIVISION OF PRECISION IBC, INC.

2" Shown

Model SS-2000

2 Piece, Standard Port

Stainless Steel Ball Valve

Features

- Pipe thread in accordance with ANSI B2.1, BS 21 1973
- 316 stainless steel
- Blow-out proof stem/standard bore
- Investment cast body
- 2000 PSI (138 BAR) W.O.G./800 PSI (55 BAR) W.O.G.
- Locking device

SIZE	D		H		L		W		KGS	TORQUE INCH/LBS	C _v (WATER)
	MM	INCH	MM	INCH	MM	INCH	MM	INCH			
1/4"	11.1	.44	45	1.77	54.0	2.13	98	3.85	0.35	40.5	6.8
3/8"	12.7	.50	45	1.77	54.0	2.13	98	3.85	0.30	40.5	6.8
1/2"	12.7	.50	47	1.85	57.2	2.25	98	3.85	0.40	48.5	9.8
3/4"	15.0	.59	51	2.00	76.2	3.00	120	4.72	0.45	73.0	25.0
1"	25.0	.79	56	2.20	85.7	3.37	120	4.72	0.65	113.4	35.0
1 1/4"	25.4	1.0	73	2.87	102	4.00	150	5.90	1.10	178.2	47.0
1 1/2"	32.0	1.3	82	3.22	111	4.37	150	5.90	1.65	210.6	81.0
2"	38.0	1.5	82	3.22	137	5.37	180	7.00	2.75	259.2	105.1

ITEM	PARTS	MATERIAL
1	Body	ASTM-A351-CF8M
2	Cap	ASTM-A351-CF8M
3	Stem	SS-316
4	Gland Nut	SS-304
5	Ball	SS-316 (CF8M)
6	Seat	R-PTFE (15% G.F)
7	Packing	PTFE
8	Thrust Washer	PTFE
9	Body Seal	PTFE
10	Stem Nut	SS-304
11	Spring Washer	SS-304
12	Handle	SS-304
13	Locking Device	SS-304
14	Sleeve	Vinyl

Save 30% -38%

P.O. Box 1171, Fairhope, AL 36533, 761 Middle Street, Fairhope, AL 36532

334-990-6789 800-544-7889 FAX: 334-990-6787

P.O. Box 1138, Broussard, LA 70518, 102 Nova Street, Broussard, LA 70518

318-839-1666 888-805-1247 FAX: 318-839-2666

SPECIFICATION SHEET

Precision Valve Products

A DIVISION OF PRECISION IBC, INC.

2" Shown

Model B-2100

2 Piece, Standard Port

Brass Ball Valve with Bronze Coating

Features

- Pipe thread in accordance with ANSI B2.1, BS 21 1973
- Teflon seats
- Blow-out proof stem
- Non-shock working pressure
- 400 PSI W.O.G.
- Saturated steam 150 PSI
- Suitable temperature range: 0° - 400°F

ITEM	PARTS	MATERIAL
1	Handle Nut	Brass Plated Steel
2	Lever Handle	C.P. Steel
3	Cover	Vinyl
4	O-Ring	NBR
5	Stem	Brass
6	Body	Bronze Coated Brass
7	Seat	Teflon
8	Ball	Hard C.P. Brass
9	Body Cap	Bronze Coated Brass

SIZE	B		L		H		D		TORQUE INCH/LBS
	MM	INCH	MM	INCH	MM	INCH	MM	INCH	
1/2"	10	.39	48	1.89	40	1.50	84	3.30	11
3/4"	15	.59	58	2.28	44	1.70	84	3.30	15
1"	19	.74	67	2.63	54	2.12	118	4.60	24
1 1/4"	24	.94	77	3.00	57	2.24	118	4.60	31
1 1/2"	32	1.26	87	3.42	65	2.50	134	5.20	43
2"	38	1.50	97	3.80	70	2.70	134	5.20	52

Save 30% - 38%

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P.O. Box 1138, Broussard, LA 70518, 102 Nave Street, Broussard, LA 70518
318-839-1688 888-865-1247 FAX: 318-839-2888

MODEL 10M

GLOBE VALVE

BILL OF MATERIALS

QTY. ASSY.	PART NAME	MATERIAL/FINISH	
		STAINLESS STEEL	CARBON STEEL
1	BODY	STAINLESS STEEL, TY 316	CARBON STEEL, ZINC. PLTD.
1	STEM	STAINLESS STEEL, TY 316	STAINLESS STEEL, TY 303
1	BONNET	STAINLESS STEEL, TY 316	CARBON STEEL, ZINC. PLTD.
1	PACKING	GRAFOIL	GRAFOIL
1	GLAND	STAINLESS STEEL, TY 316	CARBON STEEL, ZINC. PLTD.
1	PACKNUT	STAINLESS STEEL, TY 316	CARBON STEEL, ZINC. PLTD.
1	HANDLE	ZAMAK	ZAMAK
1	PIN	ST. STL. 300 SERIES	ST. STL. 300 SERIES
1	PANEL NUT	ST. STL. 300 SERIES	ST. STL. 300 SERIES

SPECIFICATIONS

MATERIAL	PRESS	TEMP
STAINLESS STEEL	6000 PSI	200°F
	2000 PSI	850°F
CARBON STEEL	6000 PSI	200°F
	2000 PSI	750°F

MAX. TEMP. W/TEFLON PACKING 500°F

SERVICE: WATER, OIL, GAS

ORDERING INSTRUCTIONS

PART NO. EXAMPLE P 10M 0 5 3 T

OPTION	BODY TYPE	MATERIAL	CONNECTIONS	OPTIONS
P	0	1	3 1/4 NPT	T
			5 3/8 NPT	
	5	5	7 1/2 NPT	
			11 3/4 NPT	
			15 1 NPT	

DIMENSIONS

1	4.25	5.38	2.44	7.25	4.75	1.26	7.50 lbs.	.47
3/4	3	3.88	1.56	5.25	3.56	.89	2.50 lbs.	.35
1/2	2.50	3.25	1.06	4.75	3.56	.89	1.50 lbs.	.28
3/8	2	2.63	.88	4.00	2.56	.76	1 lb.	.18
1/4	2	2.50	.88	4.00	2.56	.76	1 lb.	.18
SIZE	A	B	C	D	E	F	WT.	ORIFICE DIA.

Roller Chain & Links - .250 Pitch

MATERIAL: Steel

Priced Per Foot

ROLLER CHAIN			
Catalog Number	Material	Average Tensile Load - lbs.	Average Weight Per ft. - lbs.
A 6Q 7-25	Hardened	925	.09
A 6Y 7-25	Stainless	700

SPRING CLIP CONNECTING LINK

ROLLER LINK

OFFSET LINK (2 pitches)

MATERIAL: Steel

CONNECTING LINKS (FOR ROLLER CHAIN)		
Catalog Number		Type of Connecting Link
Hardened Steel	Stainless Steel	
A 6Q 7-25SCCL	A 6Y 7-25SCCL	Spring Clip
A 6Q 7-25RL	A 6Y 7-25RL	Roller
A 6Q 7-25OSCL	A 6Y 7-25OSCL	Offset

INCH

Sprockets for Roller Chain - .250 Pitch

■ STEEL

■ FOR NO. 25 SINGLE STRAND CHAINS

■ .110 FACE

Fig. 1

Fig. 2

INSERTED STEEL HUB

MATERIAL: Steel

1/2" INCH Pitch Sprockets for Roller Chain 1/250 Pitch

Catalog Number	Fig. No.	No. of Teeth	P.D.	O.D. (Ref.)	B Bore	E Length	C Hub Dia.	D Hub Proj.	S Dim.	Set Screw			
A 6C 7-25809	1	9	.731	.84	1/4	1/2	7/16	25/64	3/16	#10-32			
A 6C 7-25810		10	.809	.92			1/2						
A 6C 7-25811		11	.887	.99			9/16						
A 6C 7-25812		12	.966	1.08			5/8						
A 6C 7-25813		13	1.045	1.17			23/32						
A 6C 7-25814		14	1.124	1.24			13/16						
A 6C 7-25815		15	1.203	1.33			7/8						
A 6C 7-25816		16	1.282	1.41			31/32						
A 6C 7-25817		17	1.361	1.49			1-1/32						
A 6C 7-25818		18	1.440	1.57			1-1/8						
A 6C 7-25819		19	1.519	1.65			1-7/32						
A 6C 7-25820		20	1.598	1.73	3/8	5/8	1-9/32	33/64	1/4	1/4-20			
A 6C 7-25821		21	1.678	1.81			1-3/8						
A 6C 7-25822		22	1.757	1.89			1-7/16						
A 6C 7-25823		23	1.836	1.97			1-1/2						
A 6C 7-25824		24	1.915	2.05			1-1/2						
A 6C 7-25825		25	1.995	2.13									
A 6C 7-25826		26	2.074	2.21									
A 6C 7-25828		28	2.233	2.37									
A 6C 7-25830		30	2.392	2.53									
A 6C 7-25832		32	2.551	2.69									
A 6C 7-25836		36	2.869	3.01									
A 6C 7-25840		40	3.187	3.33	1/2	3/4	2	41/64	1/4	1/4-20			
A 6C 7-25845		45	3.584	3.73									
A 6C 7-25848		48	3.823	3.96									
A 6C 7-25854		54	4.300	4.44									
A 6C 7-25860		60	4.777	4.92									
A 6C 7-25870		70	5.572	5.72									
A 6C 7-25872		72	5.732	5.87							1/2	13/16	2
A 6C 7-25872	1	72	5.732	5.87									

NOTE: These sprockets can be used with standard #25, 1/4" pitch roller or ladder chains.
 * May be Figure 1 configuration.

TYPICAL ASSEMBLIES

500/700 4½ INCH PROCESS GAUGES

S E R I E S

45.740

4½ INCH
PHENOLIC CASE
316SS INTERNALS
DRY
½" NPT
BOTTOM CONNECTION

45.760

4½ INCH
PHENOLIC CASE
316SS INTERNALS
GLYCERINE FILLED
½" NPT
BOTTOM CONNECTION

SPECIFICATIONS	
Case	Turret Style Black Phenolic. Solid Front, Safety Case with Blow-out Back
Bayonet Ring	Threaded Black Phenolic
Lens	Acrylic. Laminated Safety Glass is Available.
Bourdon Tube	316 Stainless Steel "C" Tube for Pressures up to 600 PSI 316SS Coiled Safety Tube above 600 PSI
Connection	1/2" NPT 316 Stainless Steel
Safety Protection	Blow-out Back on the Rear of Case.
Movement	Stainless Steel with Highly Polished Bearing Surfaces. An internal zero stop is standard.
Accuracy	± 1/2% Full Scale. ANSI Grade A.
Pointer	Balanced Micro-Adjustable Aluminum, Black Finish
Dial	Aluminum, White Background with Black Markings. Single Scale PSI is Standard. PSI/kPa or PSI/Kg-cm² Dual Scale is Available as a Stock Option. On Dual Scale Dials, the Outer Scale is PSI in Black and the Inner Metric Scale is Red. UV Resistant.
Fill Liquid	(Model 45.760) Glycerine and Water. Silicone or Halocarbon are Available as Options.

STANDARD DIAL CONFIGURATIONS					
DUAL RANGE	FIGURE INTERVAL	GRADUATION INTERVAL	DIAL RANGE	FIGURE INTERVAL	GRADUATION INTERVAL
30" Hg Vacuum	5" Hg	0.2" Hg	0-200 PSI	20 PSI	2 PSI
30" Hg/15 PSI	5" Hg-3 PSI	0.5" Hg-0.2 PSI	0-300 PSI	50 PSI	2 PSI
30" Hg/30 PSI	10" Hg-5 PSI	1" Hg-0.5 PSI	0-400 PSI	50 PSI	5 PSI
30" Hg/60 PSI	10" Hg-10 PSI	1" Hg-0.5 PSI	0-500 PSI	50 PSI	5 PSI
30" Hg/100 PSI	30" Hg-10 PSI	2" Hg-1 PSI	0-800 PSI	100 PSI	5 PSI
30" Hg/160 PSI	30" Hg-20 PSI	2" Hg-1 PSI	0-1000 PSI	100 PSI	10 PSI
30" Hg/200 PSI	30" Hg-20 PSI	5" Hg-2 PSI	0-1500 PSI	200 PSI	10 PSI
30" Hg/300 PSI	30" Hg-50 PSI	5" Hg-2 PSI	0-2000 PSI	200 PSI	20 PSI
0-15 PSI	2 PSI	0.1 PSI	0-3000 PSI	500 PSI	20 PSI
0-30 PSI	5 PSI	0.2 PSI	0-5000 PSI	500 PSI	50 PSI
0-60 PSI	5 PSI	0.5 PSI	0-6000 PSI	1000 PSI	50 PSI
0-100 PSI	10 PSI	1 PSI	0-10,000 PSI	1000 PSI	100 PSI
0-160 PSI	20 PSI	1 PSI	0-15,000 PSI	2000 PSI	100 PSI

Consult factory for availability of specific models, ranges and options.

SP4 Selector unit

The SP4 is a selector switch for the various SYSCON-RKC digital indicators. A maximum of 15 SP4s can be connected to one indicator. Because it is costly to use one indicator for one input, the SP4 is an alternative. The use of this selector unit allows the measurement values of more than one point to be displayed on a single indicator. Note: When more than three of these units are used, a CS-4 power unit is required. The CS-4 allows a maximum of 14 SP4s to be connected to it.

SP-4 - [] [] * [] / Input Type

(NOT PROGRAMMABLE)

Input: _____

[]: Thermocouple
See Input Code Table Below

R: RTD

V: Voltage/Current

Transfer: _____

N: Without Transfer

T: Transfer Supplied

Mounting: _____

1: Horizontal

2: Vertical

Thermocouple Input Code

CK	Type K	CB	Type B
CJ	Type J	CE	Type E
CR	Type R	CT	Type T
CS	Type S	CN	Type N

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SIGNAL CONDITIONERS & TRANSDUCERS TRANSMITTERS AND CONVERTERS

Signal Transmitters, Isolators & Alarms

JH TECHNOLOGY, INC.

JH Technology plug-in transmitter and alarm modules provide low-cost, high-accuracy answers to many measurement, monitoring and control requirements. The broad, versatile selection of standard products covers a wide range of needs, and special designs are readily available. Input capabilities range from low-level millivolt and thermocouple signals to AC power, and include most standard transducers. Transmitters are available with or without Input/Output isolation; alarms include single- and dual-trip models. Computational modules also are available.

Features:

- ◆ All Standard Inputs & Outputs
- ◆ Custom Designs Are Available
- ◆ Quick-Status Output LEDs
- ◆ Industry-Standard Pinouts
- ◆ Full Isolation Available
- ◆ Competitive Pricing
- ◆ Quick Delivery
- ◆ Uses Standard 8 or 11 Pin Outputs
- ◆ Full 7 Year Replacement Warranty

Technical Specifications:

ACCURACY:	Generally 0.1% or better. (AC: 0.5%)
OUTPUT RANGE:	Voltage: 0/1 V min, -10/+15 V max. Current: 0/1 mA min, 0/25 mA max.
ALARM:	Single Alarm - DPDT, Dual Alarm - SPDT
CONTACTS:	5A resistive @ 115/230 VAC or 30 VDC
ALARM DEADBAND:	Adjustable 0.25 to 100%
TEMPERATURE:	+0.02%/°C or Better
STABILITY:	-10 to +60° C
POWER:	AC: 115 or 230 VAC, 2.5 VA DC: 12 or 24 VDC, 2.5 W

Detailed Specifications Available for All Conditioners Listed Below. CALL (888) 476-3728!!!

How to Order:

TRANSMITTERS

Part Number	Description	AC	DC
JH4001	RTD Transmitter	\$199	\$244
JH4001I	RTD Transmitter, Isolated	\$259	\$304
JH4003	Potentiometer Transmitter	\$175	\$220
JH4003I	Pot. Transmitter, Isolated	\$235	\$280
JH4005	Thermistor Transmitter	\$219	\$264
JH4005I	Thermistor Transmitter, Isolated	\$279	\$324
JH4006	Thermistor, 2-Thermistor Linear	\$239	\$284
JH4006I	Thermistor, 2-Thermistor Linear., Isolated.	\$299	\$344
JH4007	IC Sensor Transmitter	\$219	\$264
JH4007I	IC Sensor Transmitter, Isolated	\$279	\$324
JH4010	DC Transmitter	\$159	\$204
JH4015	4-20mA Transmitter w/24V 2-Wire Supply	\$209	\$254
JH4050	DC Transmitter, Low Drift	\$199	\$244
JH4051	Strain Gauge Transmitter	\$199	\$244
JH4051I	Strain Gauge Transmitter, Isolated	\$259	\$304
JH4100	Thermocouple Transmitter	\$199	\$244
JH4130	Thermocouple Transmitter, Isolated	\$259	\$304
JH4130L	Thermocouple Transmitter, Isolated/Linear	\$279	\$324
JH4300	DC Transmitter, Isolated	\$235	\$280
JH4300C	Current Loop Isolator	\$169	\$214
JH4305	4-20mA, Isolated w/24V 2-Wire Supply	\$269	\$314
JH4310	DC Transmitter, Isolated, (Low Drift)	\$259	\$304
JH4380P	Process Isolator	\$205	\$250

JH4380W	Wide-Range (User Rangeable) DC Isolated Transmitter	\$249	\$294
JH4400	Add/Subtract Transmitters	\$239	\$284
JH4400I	Add/Subtract Transmitters, Isolated	\$299	\$344
JH4410	Multiplying Transmitter	\$259	\$304
JH4410I	Multiplying Transmitter, Isolated	\$319	\$364
JH4420	Dividing Transmitter	\$259	\$304
JH4420I	Dividing Transmitter, Isolated	\$319	\$364
JH4430	Square Function Transmitter	\$259	\$304
JH4430I	Square Function Transmitter Isolated	\$319	\$364
JH4440	Square Root Transmitter	\$259	\$304
JH4440I	Square Root Transmitter, Isolated	\$319	\$364
JH6010I	AC Transmitter, Voltage, Input, Isolated	\$259	\$304
JH6010IR	True-RMS AC Transmitter, Voltage, Input, Isolated	\$309	\$354
JH6020I	AC Transmitter, Current, Input, Isolated	\$259	\$304
JH6020IR	True-RMS AC Transmitter, Current, Input, Isolated	\$309	\$354
JH7010	Frequency Input, Transmitter	\$209	\$254
JH7010I	Frequency Input, Transmitter, Isolated	\$269	\$314

PROCESS ALARMS

Part Number	Description	AC	DC
JH1000	DC 1 Alarm	\$145	\$190
JH1005	4-20 mA, 1 Alarm w/24V 2-Wire Supply	\$205	\$250
JH1020	DC, 2 Alarm	\$185	\$230
JH1025	4-20 mA 2 Alarm w/ 24V 2-Wire Supply	\$245	\$290
JH1090P	Process, 2 Alarm	\$235	\$280
JH1100A	Adding, 1 Alarm	\$235	\$280
JH1100S	Subtracting, 1 Alarm	\$235	\$280
JH1100M	Multiplying, 1 Alarm	\$255	\$300
JH1100D	Dividing, 1 Alarm	\$255	\$300
JH1120A	Adding, 2 Alarm	\$275	\$320
JH1120S	Subtracting, 2 Alarm	\$275	\$320
JH1120M	Multiplying, 2 Alarm	\$295	\$340
JH1120D	Dividing, 2 Alarm	\$295	\$340
JH1200	Thermocouple, 1 Alarm	\$195	\$240
JH1220	Thermocouple, 2 Alarm	\$235	\$280
JH1300	Thermistor, 1 Alarm	\$215	\$260
JH1300L	Thermistor, 1 Alarm, 2-Thermistor Linear	\$235	\$280
JH1320	Thermistor 2 Alarm	\$255	\$300
JH1320L	Thermistor 2 Alarm, 2-Thermistor Linear	\$275	\$320

JH1320L	Thermistor 2 Alarm, 2-Thermistor Linear	\$275	\$320
JH1350	IC Sensor 1 Alarm	\$215	\$260
JH1370	IC Sensor 2 Alarm	\$255	\$300
JH1400	RTD, 1 Alarm	\$195	\$240
JH1420	RTD, 2 Alarm	\$235	\$280
JH1500	Strain Gauge, 1 Alarm	\$195	\$240
JH1520	Strain Gauge, 2 Alarm	\$235	\$280
JH1600	AC, 1 Alarm	\$195	\$240
JH1600R	True-RMS AC, 1 Alarm	\$245	\$290
JH1620	AC, 2 Alarm	\$235	\$280
JH1620R	True-RMS AC, 2 Alarm	\$285	\$330
JH1700	Frequency Input, 1 Alarm	\$205	\$250
JH1720	Frequency Input, 2 Alarm	\$245	\$290
JH1800	Potentiometer Input, 1 Alarm	\$189	\$234
JH1820	Potentiometer Input, 2 Alarm	\$229	\$274

POWER SUPPLY

Part Number	Description	AC	DC
JH9046-1	Output Adjustable 1.5/15VDC	\$95	\$140
JH9046-2	Output Adjustable 15/30VDC	\$95	\$140
JH9246-24V	Dual 24V Loop Supply	\$155	--

ACCESSORIES (Required to Mount Transmitter/Alarms/Isolators)

DIN7PIN	8 Pin Socket (Din Rail or Wall/Panel Mountable)	\$7
DIN11PIN	11 Pin Socket (Din Rail or Wall/Panel Mountable)	\$9

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Transducers

multitek™

Models For Common Inputs:

- ◆ AC Current (Single/3 Phase)
- ◆ AC Voltage (Single/3 Phase)
- ◆ Frequency
- ◆ Phase Angle (Single/3 Phase)
- ◆ Watts/VARS(Single/3 Phase)
- ◆ Linear Integration
- ◆ RTD (2 or 3 Wire)
- ◆ Tap Position
- ◆ Resistance
- ◆ DC Current
- ◆ DC Voltage
- ◆ Thermocouple (Type J or K)

Transducers for:

- ◆ AC Current
- ◆ AC Voltage
- ◆ Frequency
- ◆ Phase Angle
- ◆ Watt & Var
- ◆ RTD

CALL (888) 476-3728 for Complete Specifications

How to Order:

TYPE	INPUT	OUTPUT	MODEL	PRICE
Current	5A, 1 Phase	1 mA	M100-AA1	\$88
Current	5A, 1 Phase	4-20mA	M100-AL1	\$181
Current	5A, 3 Phase	1 mA	M100-AA3	\$230
Current	5A, 3 Phase	4-20mA	M100-AL3	\$445
Current-RMS	5A, 1 Phase	1 mA	M100-AR1	\$185
Voltage	150V, 1 Phase	1 mA	M100-VA1	\$88
Voltage	150V, 1 Phase	4-20mA	M100-VL1	\$181
Voltage	150V, 3 Phase	1 mA	M100-VA3	\$230
Voltage	150V, 3 Phase	4-20mA	M100-VL3	\$445
Voltage-RMS	150V, 1 Phase	1 mA	M100-VR1	\$185
Voltage-Suppressed Zero	150V, 1 Phase	1 mA	M100-VS1	\$240
Frequency	120V, 45-55 Hz	1 mA	M100-FA1-1	\$345
Frequency	120V, 55-65 Hz	1 mA	M100-FA1-2	\$345
Frequency	120V, 45-65 Hz	1 mA	M100-FA1-3	\$345
Frequency	120V 360-440 Hz	1 mA	M100-FA1-4	\$385
Frequency	120V 45-55 Hz	4-20mA	M100-FL1-1	\$440
Frequency	120V 55-65 Hz	4-20mA	M100-FL1-2	\$440
Frequency	120V 45-65 Hz	4-20mA	M100-FL1-3	\$440
Frequency	120V 360-440 Hz	4-20mA	M100-FL1-4	\$485
Phase Angle	1 Phase, .5-1-.5 or 0-1-0, 2 or 4 Quadrant	1 mA	M100-PA1	\$330
Phase Angle	3 Phase 3/4 Wire, .5-1-.5 2 Quadrant	1 mA	M100-PA2	\$330
Phase Angle	3 Phase 3/4 Wire, 0-1-0, 4 Quadrant	1 mA	M100-PA3	\$435
Phase Angle	2 Voltages, .5-1-.5 or 0-1-0	1 mA	M100-PV1	\$330
Watts	1 Phase, 120V-5A	1 mA	M100-WA1	\$295
Watts	3 Phase 3 Wire Bal. Load, 120V-5A	1 mA	M100-WA2	\$315
Watts	3 Phase 4 Wire Bal. Load, 120V-5A	1 mA	M100-WA3	\$315
Watts	3 Phase 3 Wire Unbal. Load, 120V-5A	1 mA	M100-WA4	\$350
Watts	3 Phase 4 Wire Unbal. Load, 120V-5A	1 mA	M100-WA5	\$375
Vars	1 Phase, 120V-5A	1 mA	M100-XA1	\$295
Vars	3 Phase 3 Wire Unbal. Load, 120V-5A	1 mA	M100-XA4	\$385

Vars	3 Phase 4 Wire Unbal. Load, 120V-5A	1mA	M100-XA5	\$395
Linear Integrator	1 mA Input	1 Relay Closure	M100-DI1	\$250
Linear Integrator	1 mA Input	2 Relay Closure	M100-DI2	\$275
RTD	Plat./Copper/Nickel 10-200 Ohm	1 mA	M100-RTD	\$345
TAP	1-50K Ohm {Specify number of taps}	1 mA	M100-TAP	\$345
Resistance	0-20K Ohm	1mA	M100-RPN	\$310
DC Current	100mA...10A - 4000V Isolation	0-1mA	M100-DA1	\$355
DC Current	100mA...10A - 1500V Isolation	0-1mA	M100-DA1I	\$245
DC Current	100mA...10A - 4000V Isolation	0-1mA	M100-DS2	\$395
DC Current	100mA...10A - 4000V Isolation	0-1mA	M100-DS3	\$420
DC Voltage	20mV...11.9V - 4000V Isolation	0-1mA	M100-DV1	\$355
DC Voltage	12V...600V - 4000V Isolation	0-1mA	M100-DV2	\$355
DC Voltage	20mV...11.9V - 1500V Isolation	0-1mA	M100-DV1I	\$245
DC Voltage	12V...600V - 1500V Isolation	0-1mA	M100-DV2I	\$245

OPTIONS (Add Option Codes As a Suffix To Main Part Number)

INPUT VOLTAGES	Option Code	Price
208V	VB	\$0
240V	VC	\$25
277V	VD	\$25
480V	VE	\$25
600V	VF	\$25
INPUT FREQUENCIES	Option Code	Price
50Hz	FB	\$0
400Hz	FC	\$31
INPUT CURRENTS	Option Code	Price
1A AC	AB	\$32
10A AC	AC	\$32

POWER SUPPLY	Option Code	Price
240V AC	PB	\$25
480V AC	PC	\$35
12V DC	PD	\$35
24V DC	PE	\$35
48V DC	PF	\$35
110V DC	PG	\$70
OUTPUTS	Option Code	Price
0-20mA	OB	\$45
4-20mA	OC	\$97
0-1 V	OD	\$45
0-10V	OE	\$49
1-5V	OF	\$97

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Features:

- ◆ 100's of Styles & Sizes Available, Call with Your Spec
- ◆ Insulation Class 0.6 KV BIL 10 KV
- ◆ Conform to ANSI C57.13 & Applicable IEC Standards
- ◆ UL Recognized (Most Models)
- ◆ Multiple Frequency Ranges

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How to Order (Current Transformers):

MODEL	Type	Core ID(“)	Ratio Ranges	Starting Price
L595	Round	0.75”	20:0.1A - 400:0.1A	\$24
546	Round	1.10”	50:5A - 400:5A	\$17
2559	Square	1.13”	50:5A - 400:5A	\$18
D	Round	1.5”	25:5A - 800:5A	\$19
2560	Square	1.56”	100:5A - 1200:5A	\$25
2743	Square	2.06”	50:5A - 1500:5A	\$25
A	Round	2.25”	60:5A - 1500:5A	\$25
653	Round	2.5”	100:5A - 1600:5A	\$27
C	Round	2.88”	200:5A - 2000:5A	\$25
MW	Round	3.5”	300:5A - 4000:5A	\$30
ND-TT	Square	4.25”	500:5A - 5000:5A	\$45
K	Round	6.25”	600:5A - 6000:5A	\$53
1SP	Split	0.84 x 2”	100:5A - 400:5A	\$70
3SP	Split	2.19 x 3.25”	100:5A - 400:5A	\$83
5SP	Split	2.88 x 4.25”	100:5A - 1200:5A	\$93
7SP	Split	2.88 x 6.25”	600:5A - 3000:5A	\$120
9SP	Split	2.88 x 7.75”	1000:5A - 6000:5A	\$170
91SP	Split	4.00 x 7.5”	1000:5A - 8000:5A	\$199

How to Order (Potential Transformers):

MODEL	Size	Ratio Ranges	VA	Starting Price
2660	6” x 4.25”	120V:120V - 600:120V	75	\$99
PTW	2.9” OD to 8.2”		25 to 3000	\$41

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NOTE: 1) HYDRO @ 455 PSIG. MIN. - 1999 ADDENDA.	
ROYAL	380" SA-455 2:1 S.F.
JOGGLE	
1	326" SA-455
4	
M.A.W.P. 350 PSIG @ 400' F.	
M.D.M.T. - 20 ° F. @ 350 PSIG.	
ASME SECTION VIII DIV. 1, 1998 ADD 1999	
X-RAY: RT-4 SPOT I.S.F.G.S.	
GALLONS: 200	WT. 799 #
SERIAL NO.	

W1-465-B	REV.
FOR: FAS ENGINEERING	DATE: 2-2-00
VERT. WATER TANK	
SURFACE AREA = 52.2 SQ. FT.	
INSIDE: NONE	
OUTSIDE: S.B. # PRIME W/ INDRACANT	
ZINC # FEG. W/ ALUMINUM SACKET.	
GUL/STEVE	L-4-00
ROY E. HANSON JR. MFG	
1824 COMPTON AVE.

NOTE: 1) HYDRO @ 100 PSIG. MIN.	
.240" SA-455 2:1 S.E.	
JOGGLE	
.1875" SA-455	
M.A.W.P. 3 PSIG. @ 220' F.	
NON CODE	
X-RAY:	
GALLONS: 429	WT. 835 LBS.
SERIAL NO.	
W-1-462-B	REV. 2/3/00
FOR: PAS ENGINEERING	DATE: 2/2/00
VERT. WATER TANK	
INSIDE: UNPAINTED	
OUTSIDE: PRIME	
	L-4-99
BY: J.G./STEVE	SCALE: 3/4"=12"
ROY E. HANSON JR. MFG.	
1924 COMPTON AVE. LOS ANGELES, CA 90011	

Roy E. Hanson Jr. Mfg.

A.S.M.E. PRESSURE
VESSELS

1924 Compton Avenue ■ Los Angeles, California 90011

(213) 747 7514 (213) 747 5363

FAX: (213) 747 7724

Specification # JI 1296

Jacketed Insulation Specification

(Semi-rigid Fiberglass with Aluminum Jacket)

The insulation medium is purpose - manufactured semi-rigid premium quality fiberglass wrap with Kraft paper lining and flexible foil cover. The fiberglass filaments are laminated at 90 degrees to the facings for enhanced flexibility and compressive strength.

Installed Density:	3 lbs/ft ³
Compressive Strength:	125 lbs/in ²
R. Value:	4.17 per inch
Thermal Conductivity:	K = 0.24 Btu-in/hr-ft ² -deg F @ 75 degrees F mean
Standard Thickness:	2 inches (R 8 value)
Optional Thickness:	3 inches (R 12 value)
Max Thickness:	4 inches (R 16 value)

After installation, the insulation is clad with an aluminum jacket to ASTM B-209 with a laminated 1 mil polyethylene moisture barrier on the tank side. Standard exterior jacket finish is embossed "stucco" pattern to minimize glare and resist minor damage. All tank connections are recessed and the ASME nameplate exposed. All seams are caulked with aluminum pigmented silicone for weather protection.

Jacket Thickness:	.020" aluminum (available up to .040" thick at extra cost).
Temper:	H14 to H19
Finish:	Natural Aluminum

(Alternate jacket materials such as stainless steel or enamel coated mild steel are also available - please call for details)

Important: Minor shipping damage is more noticeable on jacketed tanks due to the uniform finish and the nature of the jacket. Extra lugs are installed on jacketed vessels for securing the tanks during shipment and they are normally palletized and shipped on a flat bed. Even so, minor cosmetic damage can occur and must be considered normal.

Table 6.2.16 ASTM Mechanical Properties (A 240, A 276, A 479, A 564, A 582) (Continued)

UNS no.	Grade	Condition*	Tensile strength, min		Yield strength, min		Elongation in 2 in or 50 mm min, %	Hardness, max	
			ksi	MPa	ksi	MPa		Brinell	Rockwell B†
Precipitation-hardening stainless steels									
S13800	XM-13/13-8Mo PH	Annealed	—	—	—	—	—	363	38HRC
		H950	220	1,520	205	1,410	10.0	430	45HRC
		H1000	205	1,410	190	1,310	10.0	400	43HRC
		H1050	175	1,210	165	1,140	12.0	372	40HRC
		H1150	135	930	90	620	14.0	283	30HRC
S15700	632/15-7PH	Annealed	—	—	—	—	—	269	100
		RH950	200	1,380	175	1,210	7.0	415	—
S17400	630/17-4PH	Annealed	—	—	—	—	—	363	38HRC
		H900	190	1,310	170	1,170	10.0	388	40HRC
		H925	170	1,170	155	1,070	10.0	375	38HRC
		H1025	155	1,070	145	1,000	12.0	331	35HRC
		H1100	140	965	115	795	14.0	302	31HRC
S17700	631/17-7PH	Annealed	—	—	—	—	—	229	98
		RH950	185	1,275	150	1,035	6.0	388	41HRC
S35500	634/AMS 355	Annealed	—	—	—	—	—	363	—
		H1000	170	1,170	155	1,070	12.0	341	37HRC
S45000	XM-25/Custom 450	Annealed	130	895	95	655	10.0	321	32HRC
		H900	180	1,240	170	1,170	10.0	363	39HRC
		H950	170	1,170	160	1,100	10.0	341	37HRC
		H1000	160	1,100	150	1,030	12.0	331	36HRC
		H1100	130	895	105	725	16.0	285	30HRC
S45500	XM-16/Custom 455	Annealed	—	—	—	—	—	331	36HRC
		H900	235	1,620	220	1,520	8.0	444	47HRC
		H950	220	1,520	205	1,410	10.0	415	44HRC
		H1000	205	1,410	185	1,280	10.0	363	40HRC

* Condition defined in applicable ASTM specification

† Rockwell B unless hardness Rockwell C HRC is indicated

‡ None required in ASTM specifications

Table 6.2.17 Maximum Allowable Stress Values (ksi), Plate: ASME Section I; Section III, Classes 2 and 3; Section VIII, Division 1

UNS no.	Grade	-20 to 100 F	300 F	400 F	500 F	600 F	650 F	700 F	750 F	800 F	850 F	900 F
Austenitic stainless steels												
S30403	304L	16.7	12.8	11.7	10.9	10.3	10.5	10.0	9.8	9.7	—*	—
S30409	304H	18.8	14.1	12.9	12.1	11.4	11.2	11.1	10.8	10.6	10.4	10.2
S30451	304N	20.0	16.7	15.0	13.9	13.2	13.0	12.7	12.5	12.3	12.1	11.8
S31603	316L	16.7	12.7	11.7	10.9	10.4	10.2	10.0	9.8	9.6	9.4	—
N08904	904L	17.8	15.1	13.8	12.7	12.0	11.7	11.4	—	—	—	—
S31254	254 SSMO	23.5	21.4	19.9	18.5	17.9	17.7	17.5	17.3	—	—	—
Duplex stainless steel												
S31803	2205	22.5	21.7	20.9	20.4	20.2	—	—	—	—	—	—
Ferritic stainless steels												
S40900	409	13.8	12.7	12.2	11.8	11.4	11.3	11.1	10.7	10.2	—	—
S43000	430	16.3	15.0	14.4	13.9	13.5	13.3	13.1	12.7	12.0	11.3	10.5
Precipitation-hardening stainless steel												
S17400	630/17-4	35.0	35.0	34.1	33.3	32.8	32.6	—	—	—	—	—

* No allowable stress values at this temperature; material not recommended for service at this temperature.

Table 6.1.4 Solubility of Gases in Water
(By volume at atmospheric pressure)

	t, °F (°C)				t, °F (°C)		
	32 (0)	68 (20)	212 (100)		32 (0)	68 (20)	212 (100)
Air	0.032	0.020	0.012	Hydrogen	0.023	0.020	0.013
Acetylene	1.89	1.12		Hydrogen sulfide	5.0	2.8	0.87
Ammonia	1,250	700		Hydrochloric acid	560	480	
Carbon dioxide	1.87	0.96	0.26	Nitrogen	0.026	0.017	0.0105
Carbon monoxide	0.039	0.023		Oxygen	0.053	0.034	0.185
Chlorine	5.0	2.5	0.00	Sulfuric acid	87	43	

tinguishes one element from another is this charge of the nucleus. It also determines the position of the element in the periodic table. Modern researches have shown the existence of isotopes, that is, two or more species of atoms having the same atomic number and thus occupying the same place in the periodic system, but differing somewhat in atomic weight. These isotopes are chemically identical and are merely different species of the same chemical element. Most of the ordinary inactive elements have been shown to consist of a mixture of isotopes. This convenient atomic model should be regarded as only a working hypothesis for coordinating a number of phenomena about which much yet remains to be known.

Calculation of the Percentage Composition of Substances Add the atomic weights of the elements in the compound to obtain its molecular weight. Multiply the atomic weight of the element to be calculated by the number of atoms present (indicated in the formula by a subscript number) and by 100, and divide by the molecular weight of the compound. For example, hematite iron ore (Fe_2O_3) contains 69.94 percent of iron by weight, determined as follows: Molecular weight of $\text{Fe}_2\text{O}_3 = (55.84 \times 2) + (16 \times 3) = 159.68$. Percentage of iron in compound = $(55.84 \times 2) \times 100 / 159.68 = 69.94$.

SPECIFIC GRAVITIES AND DENSITIES

Table 6.1.5 Approximate Specific Gravities and Densities
(Water at 39 °F and normal atmospheric pressure taken as unity) For more detailed data on any material, see the section dealing with the properties of that material. Data given are for usual room temperatures.

Substance	Specific gravity	Avg density	
		lb/ft ³	kg/m ³
Metals, Alloys, Ores*			
Aluminum, cast-hammered	2.55-2.80	165	2,643
Brass, cast-rolled	8.4-8.7	534	8,553
Bronze, aluminum	7.7	481	7,702
Bronze, 7.9-14% Sn	7.4-8.9	509	8,153
Bronze, phosphor	8.88	554	8,874
Copper, cast-rolled	8.8-8.95	556	8,906
Copper ore, pyrites	4.1-4.3	262	4,197
German silver	8.58	536	8,586
Gold, cast-hammered	19.25-19.35	1,205	19,300
Gold coin (U.S.)	17.18-17.2	1,073	17,190
Iridium	21.78-22.42	1,383	22,160
Iron, gray cast	7.03-7.13	442	7,079
Iron, cast, pig	7.2	450	7,207
Iron, wrought	7.6-7.9	485	7,658
Iron, spiegeleisen	7.5	468	7,496
Iron, ferrosilicon	6.7-7.3	437	6,984
Iron ore, hematite	5.2	325	5,206
Iron ore, limonite	3.6-4.0	237	3,796
Iron ore, magnetite	4.9-5.2	315	5,046
Iron slag	2.5-3.0	172	2,755
Lead	11.34	710	11,370
Lead ore, galena	7.3-7.6	465	7,449
Manganese	7.42	475	7,608
Manganese ore, pyrolusite	3.7-4.6	259	4,149
Mercury	13.546	847	13,570
Monel metal, rolled	8.97	555	8,688
Nickel	8.9	537	8,602

Table 6.1.5 Approximate Specific Gravities and Densities (Continued)

Substance	Specific gravity	Avg density	
		lb/ft ³	kg/m ³
Platinum, cast-hammered	21.5	1,330	21,300
Silver, cast-hammered	10.4-10.6	656	10,510
Steel, cold-drawn	7.83	489	7,832
Steel, machine	7.80	487	7,800
Steel, tool	7.70-7.73	481	7,703
Tin, cast-hammered	7.2-7.5	459	7,352
Tin ore, cassiterite	6.4-7.0	418	6,695
Tungsten	19.22	1,200	18,820
Uranium	18.7	1,170	18,740
Zinc, cast-rolled	6.9-7.2	440	7,049
Zinc, ore, blende	3.9-4.2	253	4,052
Various Solids			
Cereals, oats, bulk	0.41	26	417
Cereals, barley, bulk	0.62	39	625
Cereals, corn, rye, bulk	0.73	45	721
Cereals, wheat, bulk	0.77	48	769
Cork	0.22-0.26	15	240
Cotton, flax, hemp	1.47-1.50	93	1,491
Fats	0.90-0.97	58	925
Flour, loose	0.40-0.50	28	448
Flour, pressed	0.70-0.80	47	753
Glass, common	2.40-2.80	162	2,595
Glass, plate or crown	2.45-2.72	161	2,580
Glass, crystal	2.90-3.00	184	2,950
Glass, flint	3.2-4.7	247	3,960
Hay and straw, bales	0.32	20	320
Leather	0.86-1.02	59	945
Paper	0.70-1.15	58	929
Plastics (see Sec. 6.12)			
Potatoes, piled	0.67	44	705
Rubber, caoutchouc	0.92-0.96	59	946
Rubber goods	1.0-2.0	94	1,506
Salt, granulated, piled	0.77	48	769
Salt peter	2.11	132	2,115
Starch	1.53	96	1,539
Sulfur	1.93-2.07	125	2,001
Wool	1.32	82	1,315
Timber, Air-Dry			
Apple	0.66-0.74	44	705
Ash, black	0.55	34	545
Ash, white	0.64-0.71	42	673
Birch, sweet, yellow	0.71-0.72	44	705
Cedar, white, red	0.35	22	352
Cherry, wild red	0.43	27	433
Chestnut	0.48	30	481
Cypress	0.45-0.48	29	465
Fir, Douglas	0.48-0.55	32	513
Fir, balsam	0.40	25	401
Elm, white	0.56	35	561
Hemlock	0.45-0.50	29	465
Hickory	0.74-0.80	48	769
Locust	0.67-0.77	45	722
Mahogany	0.56-0.85	44	705
Maple, sugar	0.68	43	689
Maple, white	0.53	33	529
Oak, chestnut	0.74	46	737
Oak, live	0.87	54	866

6-8 GENERAL PROPERTIES OF MATERIALS

Table 6.1.5 Approximate Specific Gravities and Densities (Continued)

Substance	Specific gravity	Avg density	
		lb/ft ³	kg/m ³
Oak, red, black	0.64-0.71	42	673
Oak, white	0.77	48	770
Pine, Oregon	0.51	32	513
Pine, red	0.48	30	481
Pine, white	0.43	27	433
Pine, Southern	0.61-0.67	38-42	610-673
Pine, Norway	0.55	34	541
Poplar	0.43	27	433
Redwood, California	0.42	26	417
Spruce, white, red	0.45	28	449
Teak, African	0.99	62	994
Teak, Indian	0.66-0.88	48	769
Walnut, black	0.59	37	593
Willow	0.42-0.50	28	449
Various Liquids			
Alcohol, ethyl (100%)	0.789	49	802
Alcohol, methyl (100%)	0.796	50	809
Acid, muriatic, 40%	1.20	75	1,201
Acid, nitric, 91%	1.50	94	1,506
Acid, sulfuric, 87%	1.80	112	1,795
Chloroform	1.500	95	1,532
Ether	0.736	46	738
Lye, soda, 86%	1.70	106	1,699
Oils, vegetable	0.91-0.94	58	930
Oils, mineral, lubricants	0.88-0.94	57	914
Turpentine	0.861-0.867	54	866
Water			
Water, 4°C, max density	1.0	62.426	999.97
Water, 100°C	0.9584	59.812	958.10
Water, ice	0.88-0.92	56	897
Water, snow, fresh fallen	0.125	8	128
Water, seawater	1.02-1.03	64	1,025
Gases (see Sec. 4)			
Ashlar Masonry			
Granite, syenite, gneiss	2.4-2.7	159	2,549
Limestone	2.1-2.8	153	2,450
Marble	2.4-2.8	162	2,597
Sandstone	2.0-2.6	143	2,290
Bluestone	2.3-2.6	153	2,451
Rubble Masonry			
Granite, syenite, gneiss	2.3-2.6	153	2,451
Limestone	2.0-2.7	147	2,355
Sandstone	1.9-2.5	137	2,194
Bluestone	2.2-2.5	147	2,355
Marble	2.3-2.7	156	2,500
Dry Rubble Masonry			
Granite, syenite, gneiss	1.9-2.3	130	2,082
Limestone, marble	1.9-2.1	125	2,001
Sandstone, bluestone	1.8-1.9	110	1,762
Brick Masonry			
Hard brick	1.8-2.3	128	2,051
Medium brick	1.6-2.0	112	1,794
Soft brick	1.4-1.9	103	1,650
Sand-lime brick	1.4-2.2	112	1,794
Concrete Masonry			
Cement, stone, sand	2.2-2.4	144	2,309
Cement, slag, etc.	1.9-2.3	130	2,082
Cement, cinder, etc.	1.5-1.7	100	1,602
Various Building Materials			
Ashes, cinders	0.64-0.72	40-45	640-721
Cement, portland, loose	1.5	94	1,505
Portland cement	3.1-3.2	196	3,140
Lime, gypsum, loose	0.85-1.00	53-64	849-1,025
Mortar, lime, set	1.4-1.9	103	1,650
		94	1,505
Mortar, portland cement	2.08-2.25	135	2,163
Slags, bank slag	1.1-1.2	67-72	1,074-1,153
Slags, bank screenings	1.5-1.9	98-117	1,570-1,874
Slags, machine slag	1.5	96	1,538
Slags, slag sand	0.8-0.9	49-55	785-849

Table 6.1.5 Approximate Specific Gravities and Densities (Continued)

Substance	Specific gravity	Avg density	
		lb/ft ³	kg/m ³
Earth, etc., Excavated			
Clay, dry	1.0	63	1,009
Clay, damp, plastic	1.76	110	1,761
Clay and gravel, dry	1.6	100	1,602
Earth, dry, loose	1.2	76	1,217
Earth, dry, packed	1.5	95	1,521
Earth, moist, loose	1.3	78	1,250
Earth, moist, packed	1.6	96	1,538
Earth, mud, flowing	1.7	108	1,730
Earth, mud, packed	1.8	115	1,841
Riprap, limestone	1.3-1.4	80-85	1,282-1,361
Riprap, sandstone	1.4	90	1,441
Riprap, shale	1.7	105	1,681
Sand, gravel, dry, loose	1.4-1.7	90-105	1,441-1,681
Sand, gravel, dry, packed	1.6-1.9	100-120	1,602-1,922
Sand, gravel, wet	1.89-2.16	126	2,019
Excavations in Water			
Sand or gravel	0.96	60	951
Sand or gravel and clay	1.00	65	1,041
Clay	1.28	80	1,281
River mud	1.44	90	1,432
Soil	1.12	70	1,122
Stone riprap	1.00	65	1,041
Minerals			
Asbestos	2.1-2.8	153	2,451
Barytes	4.50	281	4,504
Basalt	2.7-3.2	184	2,950
Bauxite	2.55	159	2,549
Bluestone	2.5-2.6	159	2,549
Borax	1.7-1.8	109	1,746
Chalk	1.8-2.8	143	2,291
Clay, marl	1.8-2.6	137	2,196
Dolomite	2.9	181	2,901
Feldspar, orthoclase	2.5-2.7	162	2,596
Gneiss	2.7-2.9	175	2,805
Granite	2.6-2.7	165	2,644
Greenstone, trap	2.8-3.2	187	2,998
Gypsum, alabaster	2.3-2.8	159	2,549
Hornblende	3.0	187	2,998
Limestone	2.1-2.86	155	2,484
Marble	2.6-2.86	170	2,725
Magnetite	3.0	187	2,998
Phosphate rock, apatite	3.2	200	3,204
Porphyry	2.6-2.9	172	2,758
Pumice, natural	0.37-0.90	40	641
Quartz, flint	2.5-2.8	165	2,645
Sandstone	2.0-2.6	143	2,291
Serpentine	2.7-2.8	171	2,740
Shale, slate	2.6-2.9	172	2,758
Soapstone, talc	2.6-2.8	169	2,709
Syenite	2.6-2.7	165	2,645
Stone, Quarried, Piled			
Basalt, granite, gneiss	1.5	96	1,579
Limestone, marble, quartz	1.5	95	1,572
Sandstone	1.3	82	1,314
Shale	1.5	92	1,474
Greenstone, hornblend	1.7	107	1,715
Bituminous Substances			
Asphaltum	1.1-1.5	81	1,298
Coal, anthracite	1.4-1.8	97	1,554
Coal, bituminous	1.2-1.5	84	1,346
Coal, lignite	1.1-1.4	78	1,250
Coal, peat, turf, dry	0.65-0.85	47	753
Coal, charcoal, pine	0.28-0.44	23	369
Coal, charcoal, oak	0.47-0.57	33	481
Coal, coke	1.0-1.4	75	1,201
Graphite	1.64-2.7	135	2,163
Paraffin	0.87-0.91	56	898
Petroleum	0.87	54	856

Table 6.1.5 Densities

Petroleum
(kerosene)
Petroleum
Petroleum
Pitch
Tar, bituminous
Coal
Coal, anthracite
Coal, bituminous
Coal, peat
Coal, coke
Coal, charcoal

* See Sec. 4

TABLE 6.2 Value of Poisson's Ratio

Material	μ
Aluminum	0.34
Aluminum alloys	0.32
Copper	0.35
Iron	0.28
Carbon steel	0.28
Magnesium	0.33
Titanium	0.34

This ratio is known as *Poisson's ratio*, and for steel it is usually taken to be approximately 0.3. Typical values of μ for some materials are given in Table 6.2.

It is important to note that if the longitudinal strain causes extension, the lateral strain will be compressive, that is, if the applied force causes the bar to elongate in the direction of the applied force, the bar will contract in the other two directions. Similarly, if a bar is compressed (shortened) in the longitudinal direction, it will undergo an increase in its lateral dimensions.

ILLUSTRATIVE PROBLEM 6.9

A steel bar 1 in. $\times$ 1 in. $\times$ 10 in. is subjected to an axial tensile stress of 20 000 psi (Fig. 6.11). Determine the axial elongation, the lateral contraction, the final volume, and the volumetric strain. Use $E = 30 \times 10^6$ psi and $\mu = 0.3$.

FIGURE 6.11 Illustrative Problem 6.9.

SOLUTION

The axial stress is 20 000 psi. Therefore the axial strain ϵ is $S/E = 20\,000/(30 \times 10^6) = 0.000\,667$ in./in. The lateral strain is $\mu\epsilon = 0.3(0.000\,667) = 0.000\,20$ in./in. The elongation of the 10-in. length is $10 \times 0.000\,667 = 0.006\,67$ in. The contraction of each side is $1 \times 0.000\,20 = 0.000\,20$ in. The final dimensions of the bar are 10.006 67 in., 0.9998 in., and 0.9998 in.

Remember that even though the strains appear as small numbers, they are sig-

nificant and material behavior.

When be found b separately. attention to compression.

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6.7 STATICAL

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A steel Fig. 6.1 Determ

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TABLE A-1 Average Mechanical Properties of Selected Materials

Material	U.S. Customary Units			SI Units			Coefficient of Thermal Expansion 10 ⁻⁶ m/m °C	μ
	Yield Stress (psi)	Modulus of Elasticity (psi)		Yield Stress (MPa)	Modulus of Elasticity (GPa)			
		Tension, <i>E</i>	Shear, <i>G</i>		Tension, <i>E</i>	Shear, <i>G</i>		
Steel (SAE 1020)	36 000	30 000 000	12 000 000	250	210	85	11.7	0.27
Steel (SAE 1090)	65 000	30 000 000	12 000 000	450	210	85	11.7	0.27
Cast iron	80 000	15 000 000	6 000 000	560	105	40	12.1	0.20
Aluminum, 6061 alloy	35 000	10 000 000	4 000 000	240	70	30	23.6	0.33
Brass	15 000	15 000 000	6 000 000	105	105	40	18.9	0.35
Bronze	20 000	15 000 000	6 500 000	140	105	45		
Copper, hard-drawn	35 000	17 000 000	6 000 000	240	115	40	32.4	
Douglas fir timber (air dry, parallel to grain)		1 700 000			12		5.4	
Lead	2 000	2 000 000	700 000	14	14	4.9	29.5	0.43
Stainless steel	80 000	28 000 000	9 500 000	560	193	66.5	17.3	0.30
Titanium alloy	120 000	15 900 000	6 200 000	840	110	43.4	8.3	0.34