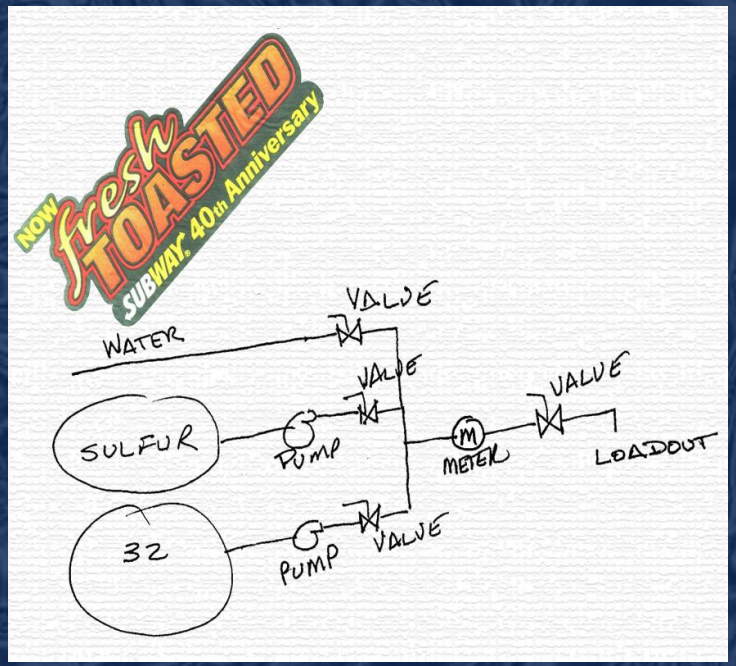
Designing an Efficient Liquid Plant

Requires

- Selecting the Right Equipment Components

Design with Direction

- Develop a plan
- Work from a flow diagram
  - Simple Flow Diagram
  - Cad designed diagram
- Allow a realistic time frame



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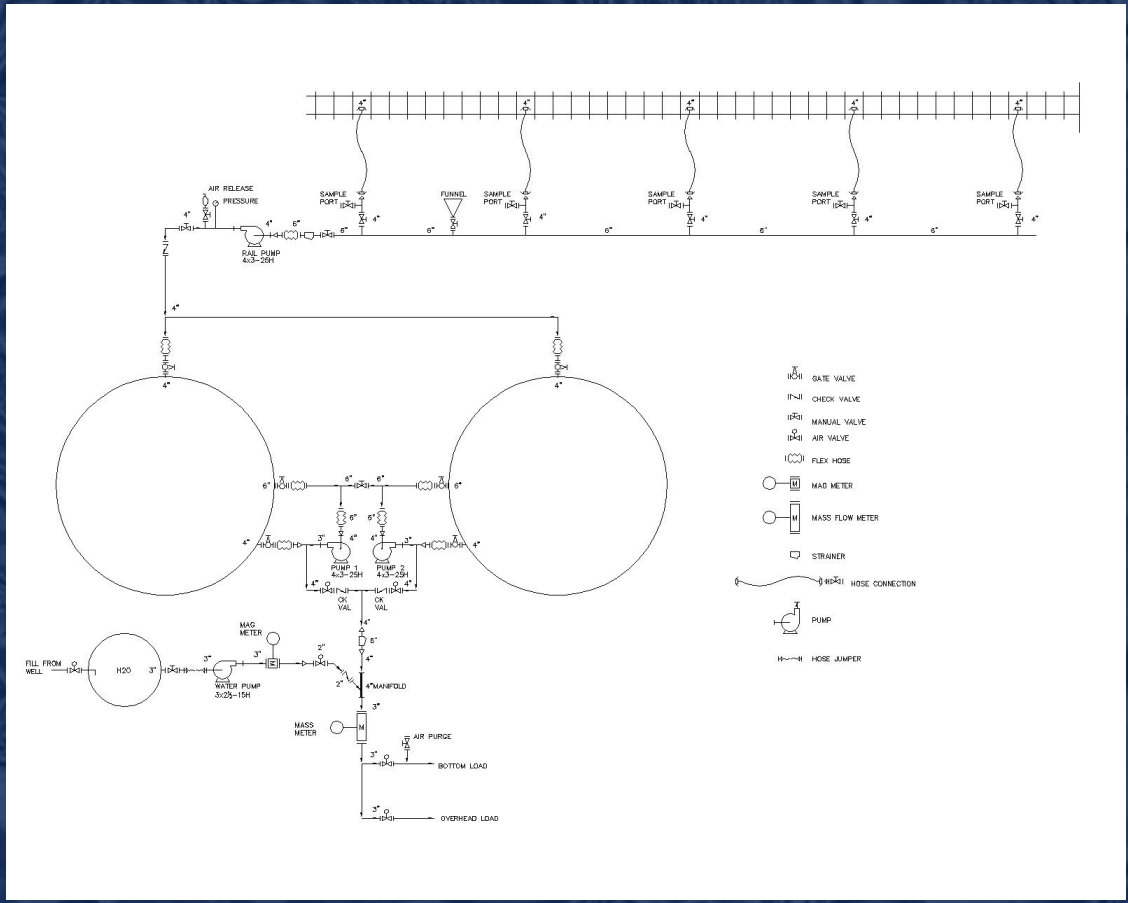

Common Themes

- Material of construction
- Product mix
- System capacity
- Quality control
- Labor
- Available power

Storage Requirements

- Turnover
- Products
- Seasonal storage
- Secondary Containment

Tanks

- Size
- Shape
- Material
- Fittings
- Foundation

Plumbing

- Size
  - Suction vs. Discharge
  - 2” to 150 gpm
  - 3” to 300 gpm
  - 4” to 450 gpm
  - 6” to 800 gpm
  - Upsize long runs

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Selection Criteria

- Flow characteristics
- Corrosion resistance
- Strength
- Cost of Installation
- Flexibility for changes
- Weld or thread?

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FRICTION LOSSES THROUGH SCREW PIPE FITTINGS IN TERMS OF EQUIVALENT LENGTHS OF STANDARD PIPE

Nominal Pipe Size Inches	Actual Inside Diameter Inches	Gate Valve	Long-Sweep Elbow or on Run of Standard Tee	Medium—Sweep Elbow or on Run of Tee Reduced in Size ¼	Standard Elbow or on Run of Tee Reduced in Size ½	Angle Valve	Close Return Bend	Tee Through Side Outlet	Globe Valve
Factor of Resistance		0.25	0.33	0.42	0.67	0.90	1.00	1.33	2.00
¼	0.662	0.335	0.442	0.56	0.89	1.20	1.34	1.79	2.68
¾	0.824	0.475	0.627	0.79	1.27	1.71	1.90	2.52	3.80
1	1.049	0.640	0.844	1.07	1.72	2.30	2.56	3.40	5.12
1¼	1.38	0.902	1.19	1.51	2.42	3.24	3.61	4.80	7.22
1½	1.61	1.09	1.43	1.83	2.92	3.92	4.36	5.79	8.72
2	2.06	1.49	1.96	2.50	3.99	5.36	5.96	7.92	11.92
2½	2.46	1.86	2.46	3.13	5.00	6.72	7.47	9.93	14.94
3	3.06	2.46	3.25	4.11	6.66	8.87	9.86	13.11	19.72
4	4.026	3.44	4.53	5.77	9.22	12.37	13.70	18.28	27.50
5	5.047	4.57	6.00	7.68	12.20	16.47	18.30	24.33	36.60
6	6.065	5.72	7.55	9.61	15.30	20.61	22.90	30.45	45.00
7	7.024	6.90	9.10	11.60	18.50	24.84	27.60	36.70	55.20
8	7.981	8.10	10.70	13.60	21.71	29.16	32.40	43.09	64.80
10	10.020	10.70	14.10	17.97	28.70	38.52	42.80	56.92	85.60
12	12.090	12.50	17.80	22.68	36.28	48.60	54.00	71.82	108.00

FRICTION LOSS OF WATER IN FEET PER 100 FEET LENGTH OF PIPE—BASED ON WILLIAMS & HAZEN FORMULA USING CONSTANT 100. SIZES OF STANDARD PIPE IN INCHES

U.S. Gals. per min.	½" Pipe		¾" Pipe		1" Pipe		1¼" Pipe		1½" Pipe		2" Pipe		2½" Pipe		3" Pipe		4" Pipe		5" Pipe		6" Pi	
	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	
2	2.10	7.4	1.20	1.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
4	4.21	27.0	2.41	7.0	1.49	2.14	.86	.57	.63	.26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
6	6.31	57.0	3.61	14.7	2.23	4.55	1.29	1.20	.94	.56	.61	.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	
8	8.42	98.0	4.81	25.0	2.98	7.8	1.72	2.03	1.26	.95	.82	.33	.52	.11	.....	.....	.....	.....	.....	.....	.....	
10	10.52	147.0	6.02	38.0	3.72	11.7	2.14	3.05	1.57	1.43	1.02	.50	.65	.17	.45	.07	.....	.....	.....	.....	.....	
12	.....	.....	7.22	53.0	4.46	16.4	2.57	4.3	1.89	2.01	1.23	.79	.78	.23	.54	.10	.....	.....	.....	.....	.....	
15	.....	.....	9.02	80.0	5.60	25.0	3.21	6.5	2.36	3.00	1.53	1.08	.98	.36	.68	.15	.....	.....	.....	.....	.....	
18	.....	.....	10.84	108.2	6.69	35.0	3.86	9.1	2.83	4.24	1.84	1.49	1.18	.50	.82	.21	.....	.....	.....	.....	.....	
20	.....	.....	12.03	136.0	7.44	42.0	4.29	11.1	3.15	5.20	2.04	1.82	1.31	.61	.91	.25	.51	.06	.....	.....	.....	
25	.....	.....	.....	.....	9.30	64.0	5.36	16.6	3.80	7.30	2.55	2.73	1.63	.92	1.13	.38	.64	.09	.....	.....	.....	
30	.....	.....	.....	.....	11.15	89.0	6.43	23.0	4.72	11.0	3.06	3.84	1.96	1.29	1.36	.54	.77	.13	.49	.04	.....	
35	.....	.....	.....	.....	13.02	119.0	7.51	31.2	5.51	14.7	3.57	5.10	2.29	1.72	1.59	.71	.89	.17	.57	.06	.....	
40	.....	.....	.....	.....	14.88	152.0	8.58	40.0	6.30	18.8	4.08	6.6	2.61	2.20	1.82	.91	1.02	.22	.65	.08	.....	
45	.....	.....	.....	.....	.....	.....	9.65	50.0	7.08	23.2	4.60	8.2	2.94	2.80	2.04	1.15	1.15	.28	.73	.09	.....	
50	.....	.....	.....	.....	.....	.....	10.72	60.0	7.87	28.4	5.11	9.9	3.27	3.32	2.27	1.38	1.28	.34	.82	.11	.57	
55	.....	.....	.....	.....	.....	.....	11.78	72.0	8.66	34.0	5.62	11.8	3.59	4.01	2.45	1.58	1.41	.41	.90	.14	.62	
60	.....	.....	.....	.....	.....	.....	12.87	85.0	9.44	39.6	6.13	13.9	3.92	4.65	2.72	1.92	1.53	.47	.98	.16	.68	
65	.....	.....	.....	.....	.....	.....	13.92	99.7	10.23	45.9	6.64	16.1	4.24	5.4	2.89	2.16	1.66	.53	1.06	.19	.74	
70	.....	.....	.....	.....	.....	.....	15.01	113.0	11.02	53.0	7.15	18.4	4.58	6.2	3.18	2.57	1.79	.63	1.14	.21	.79	
75	.....	.....	.....	.....	.....	.....	16.06	129.0	11.80	60.0	7.66	20.9	4.91	7.1	3.33	3.00	1.91	.73	1.22	.24	.85	
80	.....	.....	.....	.....	.....	.....	17.16	145.0	12.59	68.0	8.17	23.7	5.23	7.9	3.63	3.28	2.04	.81	1.31	.27	.91	
85	.....	.....	.....	.....	.....	.....	18.21	163.8	13.38	75.0	8.68	26.5	5.56	8.1	3.78	3.54	2.17	.91	1.39	.31	.96	
90	.....	.....	.....	.....	.....	.....	19.30	180.0	14.71	84.0	9.19	29.4	5.88	9.8	4.09	4.08	2.30	1.00	1.47	.34	1.02	
95	.....	.....	.....	.....	.....	.....	.....	.....	14.95	93.0	9.70	32.6	6.21	10.8	4.22	4.33	2.42	1.12	1.55	.38	1.08	
100	.....	.....	.....	.....	.....	.....	.....	.....	15.74	102.0	10.21	35.8	6.54	12.0	4.54	4.96	2.55	1.22	1.63	.41	1.13	
110	.....	.....	.....	.....	.....	.....	.....	.....	17.31	122.0	11.23	42.9	7.18	14.5	5.00	6.0	2.81	1.46	1.79	.49	1.25	
120	.....	.....	.....	.....	.....	.....	.....	.....	18.89	143.0	12.25	50.0	7.84	16.8	5.45	7.0	3.06	1.17	1.96	.58	1.36	
130	.....	.....	.....	.....	.....	.....	.....	.....	20.46	166.0	13.28	58.0	8.48	18.7	5.91	8.1	3.31	1.97	2.12	.67	1.47	
140	.....	.....	.....	.....	.....	.....	.....	.....	22.04	190.0	14.30	67.0	9.15	22.3	6.35	9.2	3.57	2.28	2.29	.76	1.59	
150	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.32	76.0	9.81	25.5	6.82	10.5	3.82	2.62	2.45	.88	1.70	
160	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16.34	86.0	10.46	29.0	7.26	11.8	4.08	2.91	2.61	.98	1.82	
170	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17.36	96.0	11.11	34.1	7.71	13.3	4.33	3.26	2.77	1.08	1.92	
180	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.38	107.0	11.76	35.7	8.17	14.0	4.60	3.61	2.94	1.22	2.04	
190	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.40	118.0	12.42	39.6	8.63	15.5	4.84	4.01	3.10	1.35	2.16	
200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.42	129.0	13.07	43.1	9.08	17.8	5.11	4.4	3.27	1.48	2.27	
220	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22.47	154.0	14.38	52.0	9.99	21.3	5.62	5.2	3.59	1.77	2.50	
240	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.51	182.0	15.69	61.0	10.89	25.1	6.13	6.2	3.92	2.08	2.72	
260	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.55	211.0	16.99	70.0	11.80	29.1	6.64	7.2	4.25	2.41	2.95	
280	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.30	81.0	12.71	33.4	7.15	8.2	4.58	2.77	3.18	
300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.61	92.0	13.62	38.0	7.66	9.3	4.90	3.14	3.40	
320	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.92	103.0	14.52	42.8	8.17	10.5	5.23	3.54	3.64	
340	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22.22	116.0	15.43	47.9	8.68	11.7	5.54	3.97	3.84	
360	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23.53	128.0	16.34	53.0	9.19	13.1	5.87	4.41	4.08	
380	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.84	142.0	17.25	59.0	9.69	14.0	6.19	4.86	4.31	
400	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.14	156.0	18.16	65.0	10.21	16.0	6.54	5.4	4.55	
450	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.40	78.0	11.49	19.8	7.35	6.7	5.11	
500	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22.70	98.0	12.77	24.0	8.17	8.1	5.68	
550	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.96	117.0	14.04	28.7	8.99	9.6	6.25	
600	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	27.23	137.0	15.32	33.7	9.80	11.3	6.81	
650	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16.59	39.0	10.62	13.2	7.38	
700	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17.87	44.9	11.44	15.1	7.95	
750	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.15	51.0	12.26	17.2	8.50	
800	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.42	57.0	13.07	19.4	9.08	
850	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21.70	64.0	13.89	21.7	9.65	
900	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22.98	71.0	14.71	24.0	10.20	

- Doubling the diameter of a pipe increases its capacity four times

Plumbing Materials

- Hose
- PVC
- Mild steel
- Stainless steel
- Poly
- Combinations

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Cost Comparison Plumbing Materials

Material	3” Pipe	4” Pipe	3” Elbow	4” Elbow	Durability
Polyethylene	$3.00	$5.00	$17.00	$24.00	Lifetime
Poly Helix EPDM Lined Hose	$4.00	$6.50			3-4 years
Sch80PVC	$5.00	$7.00	$9.00	$14.00	4-6 years
Rubber wire Reinforcement	$5.00	$7.80			6-8 years
Steel Pipe	$11.00	$16.50	$19.00	$40.00	10-18 years
Sch10SS Pipe	$16.00	$23.00	$23.00	$33.00	Lifetime

System using hose and prefabricated stainless steel fittings.

Pumps and Plumbing

- System Capacity
  - Load size
  - Time
  - Plan for growth

Don’t Get Stuck with the Wrong Pump!

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Pump Selection

- Type
  - Self-priming centrifugal
  - Straight centrifugal
  - Positive displacement
- Capacity (not size)
- Material
- Seals & packing

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Self Priming

Straight Centrifugal

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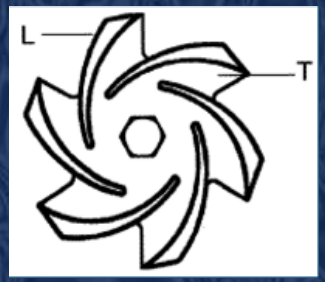
Positive Displacement

Pump Performance

- Design
- Impeller
  - Size
  - Shape
- Speed

Open vs. closed impeller design pumps

Open 	The fluid enters the eye of the impeller where the turning vanes add energy to the fluid and direct it to the discharge nozzle. A close clearance between the vanes and the pump volute, or back plate in a few designs, prevents most of the fluid from recirculating back to the eye of the impeller. (L) shows the leading edge or higher-pressure side of the impeller. (T) describes the trailing edge of the impeller
Closed 	The fluid enters the eye of the impeller where the vanes add energy to the fluid and direct it to the discharge nozzle. There is no impeller to volute or back plate clearance to set. Wear rings restrict the amount of discharge fluid that recirculates back to the suction side of the impeller. When this wear ring clearance becomes excessive the wear rings must be replaced.

Advantages and Disadvantages

- **Closed Impeller**
  - The impeller can clog if you pump solids or "stringy material". It's difficult to clean out these solids from between the shrouds and vanes.
  - The impeller is difficult to cast because the internal parts are hidden and hard to inspect for flaws
  - The impeller is difficult to modify to improve its performance
  - No impeller adjustment is possible. Once the wear ring clearances doubles they have to be replaced. This means the pump had to be disassembled just to check the status of the wear rings.
  - The closed impeller is a more complicated and expensive design not only because of the impeller, but the additional wear rings are needed.

Advantages and Disadvantages

- **Open Impeller**
  - Efficiency can be maintained through impeller clearance adjustment.
  - The impeller can be adjusted to compensate for wear and stay close to its best efficiency. No pump disassembly is necessary.
  - The open impeller is less likely to clog with solids, but if it does, it is easy to clean.
  - The open impeller has all the parts visible, so it's easy to inspect for wear or damage
  - The pump is less costly to build with a simple open impeller design.
  - The vanes can easily be cut or filed to increase the capacity.
  - You have a greater range of specific speed choices.

Pump Curve

- Flow rate vs. head
- Horsepower
- NPSH
- Efficiency

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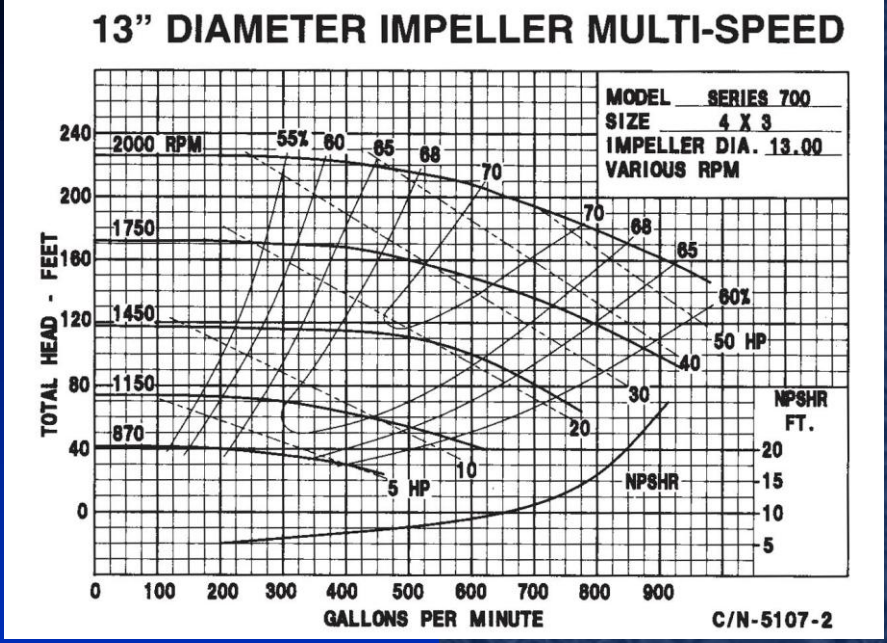

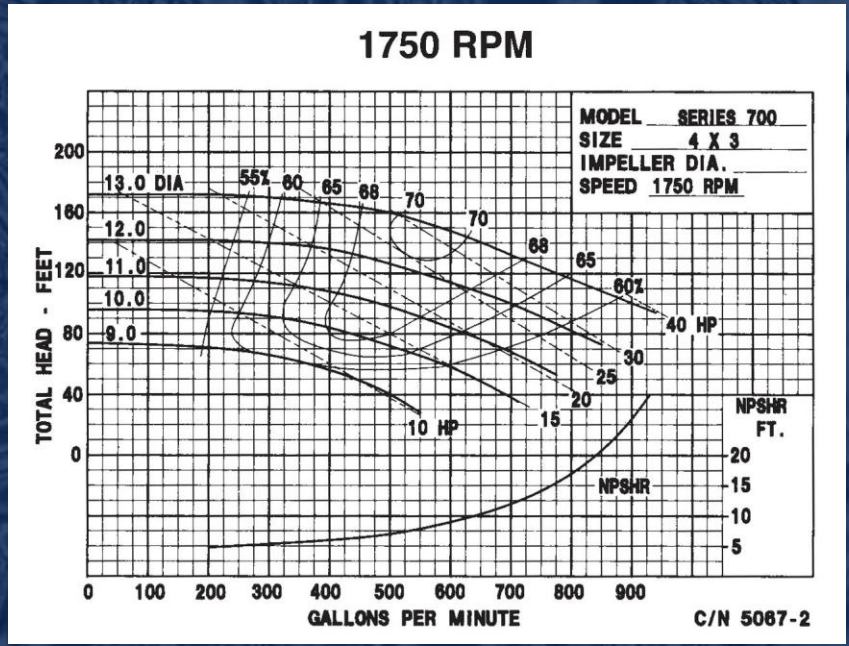

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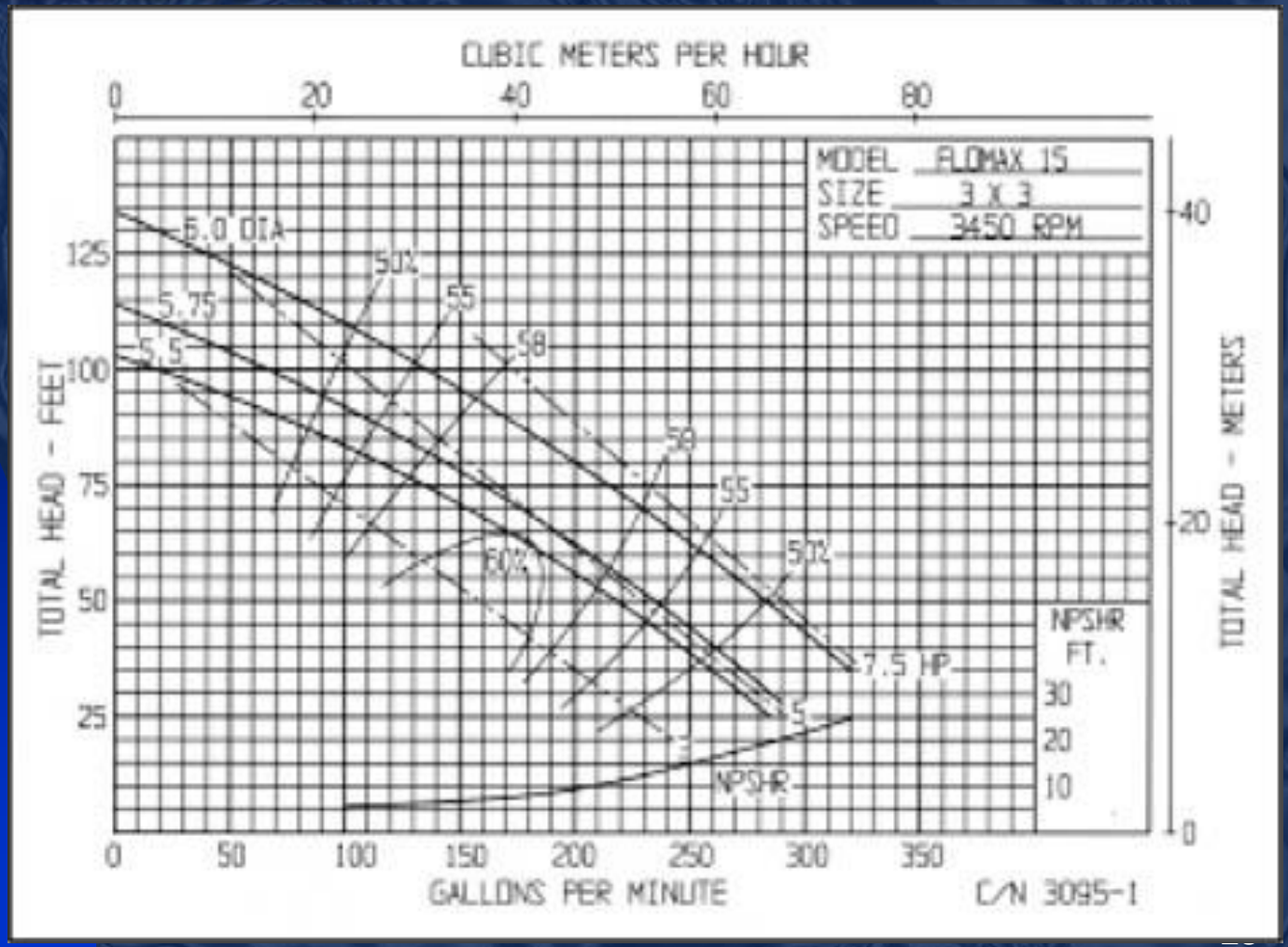

Pump & Plumbing Examples Good and Not So Good


AMMONIA
NO
SMOKING


MURRAY
EQUIPMENT
INC.
Fort Wayne, IN 46808
UN 32
15

Don’t Let Your Plumbing Get Out of Control!

Measurement

- Scales
- Meters
  - Flow rate
  - Accuracy
    - Quality control
    - Custody transfer

Types of Meters

- Positive Displacement
- Turbine/Squirrel cage
- Electromagnetic
- Coriolis Mass Flow

Positive Displacement

- Liquid moves into a measuring chamber and the number of “bites” are counted
- Volumetric
- Accuracy of some affected more than others by changes in product and flow.
- Lots of moving parts.

Turbine Meters

- Volumetric
- Liquid moving through meter causes rotor to turn in proportion to flow rate
- Straight pipe requirement
  - Inlet 20X pipedia – outlet 10X pipedia
- Changes in flow rate and viscosity can have large effect on accuracy
- Some moving parts

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“Mag” Meters

- Volumetric.
- Measures velocity of liquid through a tube of known area.
- Liquid must be electrically conductive.
- Highly accurate across large range of flow rates and viscosities.
- Less straight pipe needed.
- No moving parts to wear out.

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Mass Flow Meters

- Measures mass or weight.
- Some accurate to .10% of flow rate.
- Doesn’t care what liquid it’s measuring.
- High turndown ratio.
- Only moving parts are oscillating tubes.

Calibrate!

- All meters can lose calibration over time
- Mechanical types more susceptible to wear
  - Flow rate
  - Compatibility
- If calibrating volumetric meters by weight, know the true density of the product.

Controlling the Flow

- Valves
- Manifolds
- Control systems

Valve Selection

- Style
- Construction
- Operation

Types of Valves

- Ball valves
- Butterfly valves
- Gate valves
- Check valves

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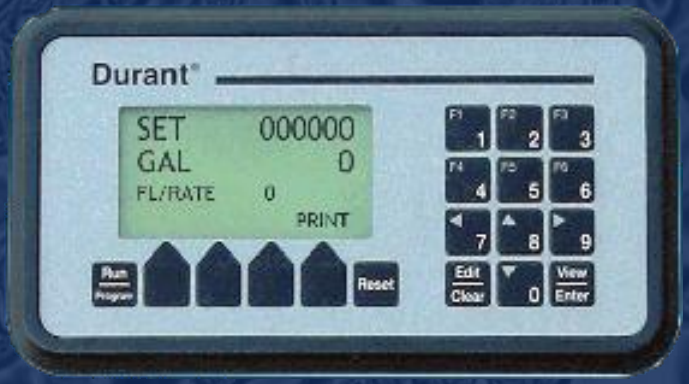
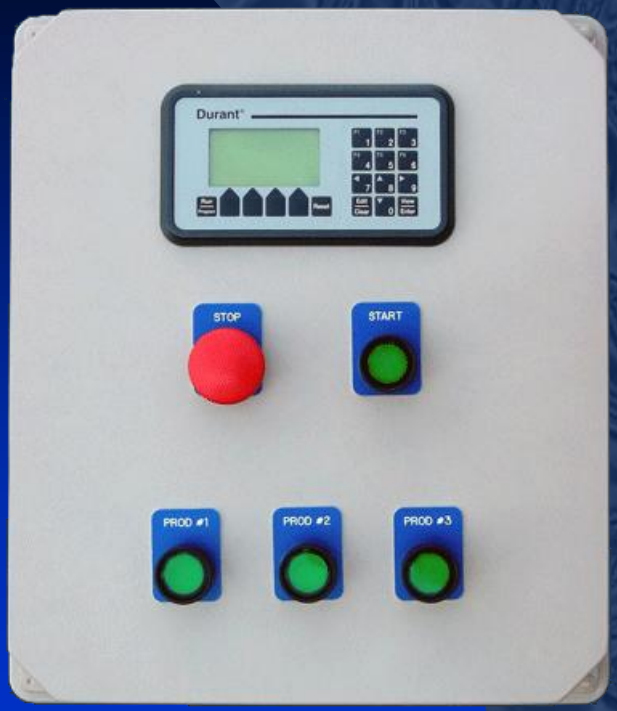
Control Systems

- Manual
- Actuated valves
- Presets
- Automation



MEI Fusion Preset



- Easy to read LCD Display, even in bright sunlight
- Print function with time & date
- Adjustable pre-act, compensates for product over-runs
- Corrosion resistant, NEMA 4X, FRP – 12:X14” enclosure
- Pre-wired, easy to install
- Compatible with most meters
- Direct upgrade replaceable for existing MEI Preset Controls
- Programmable Display
  - Total Products ID’s
  - Flow Rate Preset

Control Systems

- Manual
- Actuated valves
- Presets
- Automation

MURRAY EQUIPMENT INC.

Mix Systems

- Custom design – purpose built
- Tons per day required
  - small custom blends
- Truck load quantities
- Push products into mix tanks
- Rely on plant pump to draw products
- 1,000 tons per day – sure all liquids pumped & metered – use dump pit


Palmer


S175


WACONIA


CAUTION

Organize your work, utilize your plan and you'll avoid making a mess !

Thank you