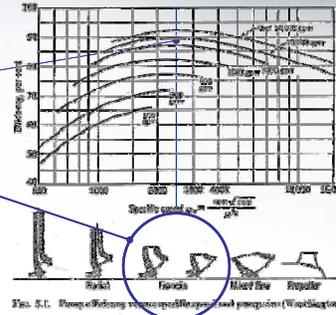


## Hydraulic Design Considerations



### Specific Speed and Efficiency

- For a particular flow rate, there is a maximum possible efficiency ( $\eta_{MAX}$ )
- For example, at 1600 M<sup>3</sup> (7040 usgpm),  $\eta_{MAX}$  is 89%
- At 1600 M<sup>3</sup>,  $\eta_{MAX}$  can only be achieved by a pump that has a  $N_s = 2500$



Introduction to Submerged Motor Cryogenic Pumps



From the Stepanoff diagram, it can be seen that, for any rate of pump flow, there is maximum possible value of hydraulic efficiency.

From the API 610 Data Sheet, In the case of a typical Loading pump with a desired rate of flow of **1600 M<sup>3</sup>/hr** (7040 usgpm) at **146 M** head, that maximum hydraulic efficiency will be **89%**.

That efficiency will only be possible from pumps designed at about  $N_s$  nearly **2500**.

The circle on the diagram indicates the type of pump impellers needed to achieve good efficiency.

Using the specific speed equation

$$NS = N X( Q^{1/2}) / H^{3/4}$$

$$2500 = (1480 X( 7040 )^{1/2}) / H^{3/4}$$

solving for H:

$$H = 181 \text{ ft} = 56 \text{ M} / \text{stage}$$

Since the desired Head is **146 M**, the Designer will design a three stage pump to produce

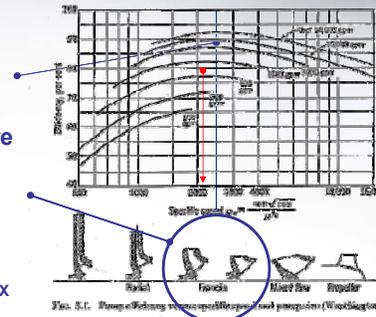
$$H = 3 X 56 = 168 \text{ M} \text{ and trim the impellers to suit.}$$

## Hydraulic Design Considerations



### Specific Speed and Efficiency

- For a particular flow rate, there is a maximum possible efficiency ( $\eta_{MAX}$ )
- For example, at 152 m<sup>3</sup>/h (669 usgpm),  $\eta_{MAX}$  is 78%
- At 152 m<sup>3</sup>/h,  $\eta_{MAX}$  can only be achieved by a pump that has a  $N_s = 2200$



Introduction to Submerged Motor Cryogenic Pumps



From the Stepanoff diagram, it can be seen that, for any rate of pump flow, there is maximum possible value of hydraulic efficiency.

In the case of GASCAN rate of flow of **152 m<sup>3</sup>/h** (669 usgpm) at **194 m** (637 ft) head. The maximum hydraulic efficiency will be **78%**.

That efficiency will only be possible from pumps designed at about  $N_s$  nearly **2200**. The closest  $N_s$  pump that Carter manufactures is 2000.

Using the specific speed equation

$$N_s = N \times (Q^{1/2}) / H^{3/4}$$

$$2000 = (3000 \times (669)^{1/2}) / H^{3/4}$$

solving for H:

$$H = 130 \text{ ft} = 40 \text{ m / stage}$$

Since the desired Head is **194 m**, the result is a five stage pump, (194 m/40 m = 4.9 stages). Carter hasn't supplied this particular impeller diameter before. Therefore, our cost would increase due to additional engineering hours. We do have a 2000  $N_s$  pump that produces 51 m/stage. This pump could be used if the speed were reduced 2500 rpm.

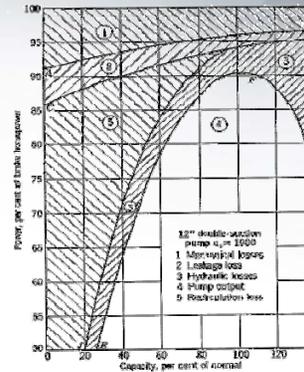
## Hydraulic Design Considerations



**Maximum Efficiency minus  
Losses = Actual Efficiency**

**Cryogenic Pump losses are of four types**

- Mechanical losses
  - Bearings and bushings
- Leakage
  - Wear Rings
  - Balance System
  - Motor Cooling
- Hydraulic Losses
  - Fluid friction
- Recirculation Losses



Introduction to Submerged Motor Cryogenic Pumps



The diagram to the right is reproduced from the book “Centrifugal and Axial Flow Pumps” by A. Stepanoff, Second Edition, 1957, page 197. The diagram is for a conventional pump.

The diagram shows that there are four kinds of pump losses.

1. Mechanical losses stay constant over the full range of pump operation, and therefore become less important as flow increases.
2. Leakage losses are a function of pump head, and therefore increase as flow decreases
3. Hydraulic losses refer to the friction losses that occur as a result of fluid friction
4. Recirculation losses occur as a result of fluid recirculation within each impeller, each diffuser, the inducer and the inducer guide vane. And which increases as the flow rate approaches zero..

Reducing the first three kinds of losses reduces pump operating cost.

The fourth kind of loss, Recirculation loss is the kind of loss that causes vibration, which begins to be significant at 70% of BEP flow. This is why Pump Manufacturers recommend that pumps should not be oversized.