PUMP TECHNOLOGY

Are we making any progress?

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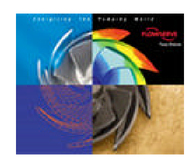
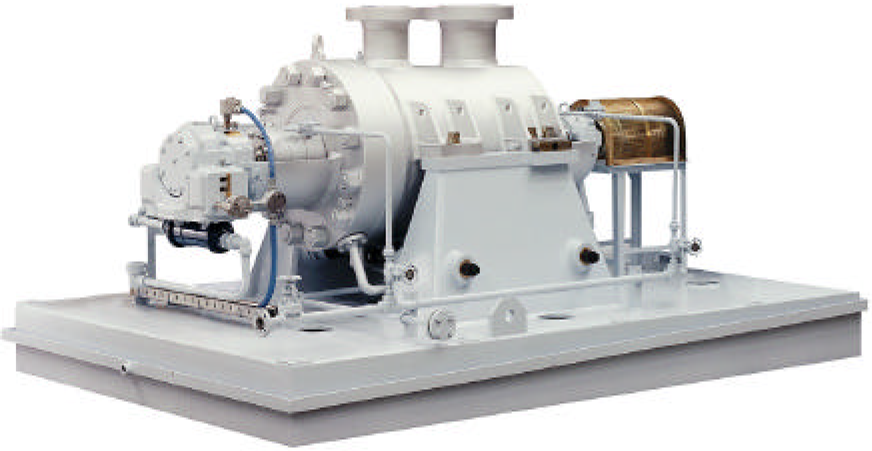
Flowserve Corporation
Pump Division
Vernon, California

ASME FEDSM May 31, 2001



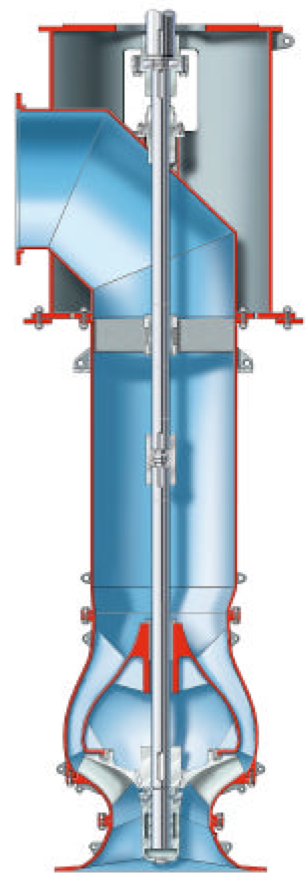
“LARGEST PUMP”

- HIGHEST HORSEPOWER
  - American Electric Power John E. Amos plant
  - Boiler Feed Pump - Multistage, Barrel
  - 21,800 GPM
  - 11,300 ft TDH
  - 4160 RPM
  - **63,200 HP**
  - 1973



“LARGEST PUMP”

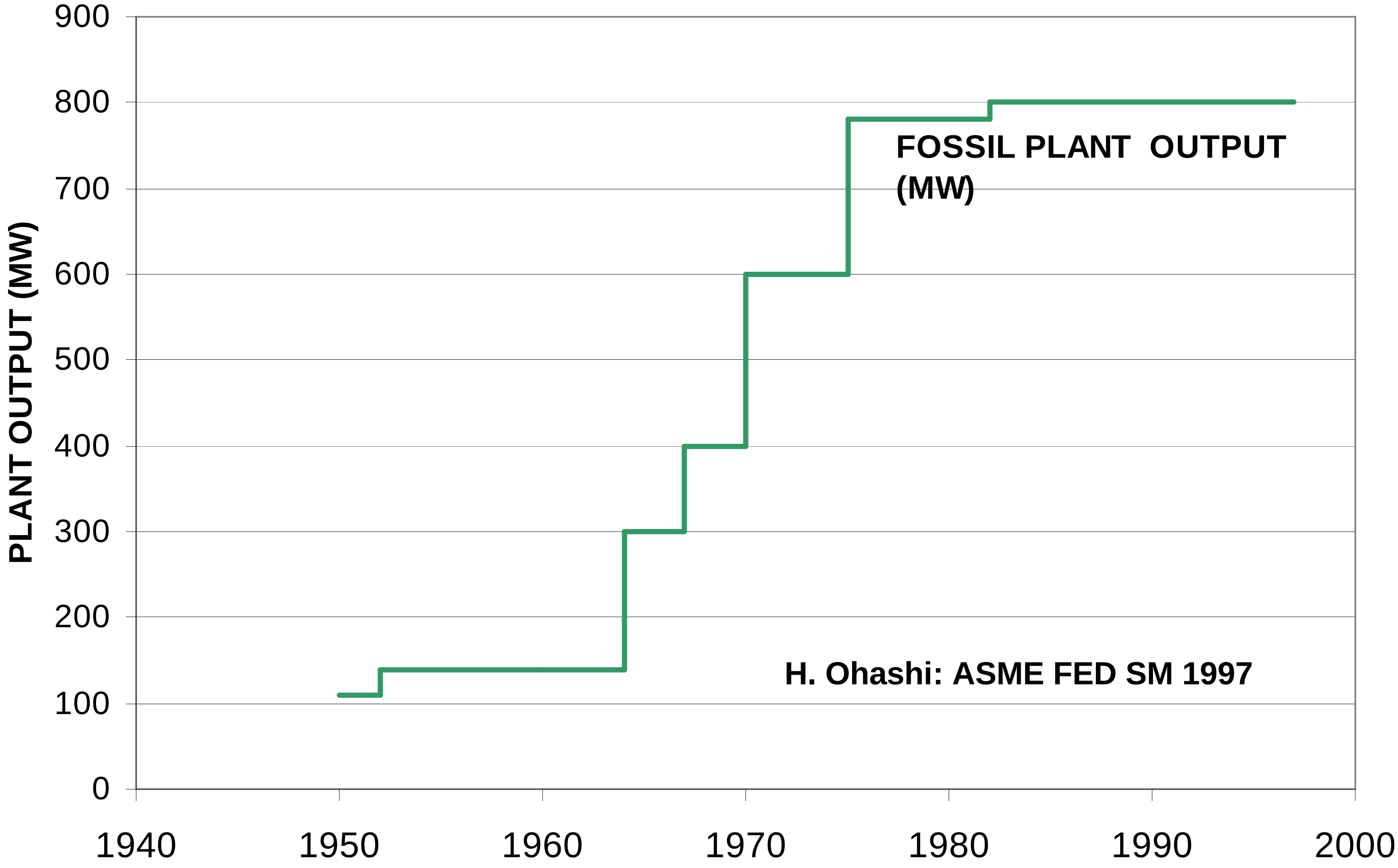
- HIGHEST CAPACITY
  - South Florida - Mill Creek
  - Flood Control
  - **695,000 GPM**
  - 180 RPM
  - 24 ft TDH
  - 5000 HP
  - 1985



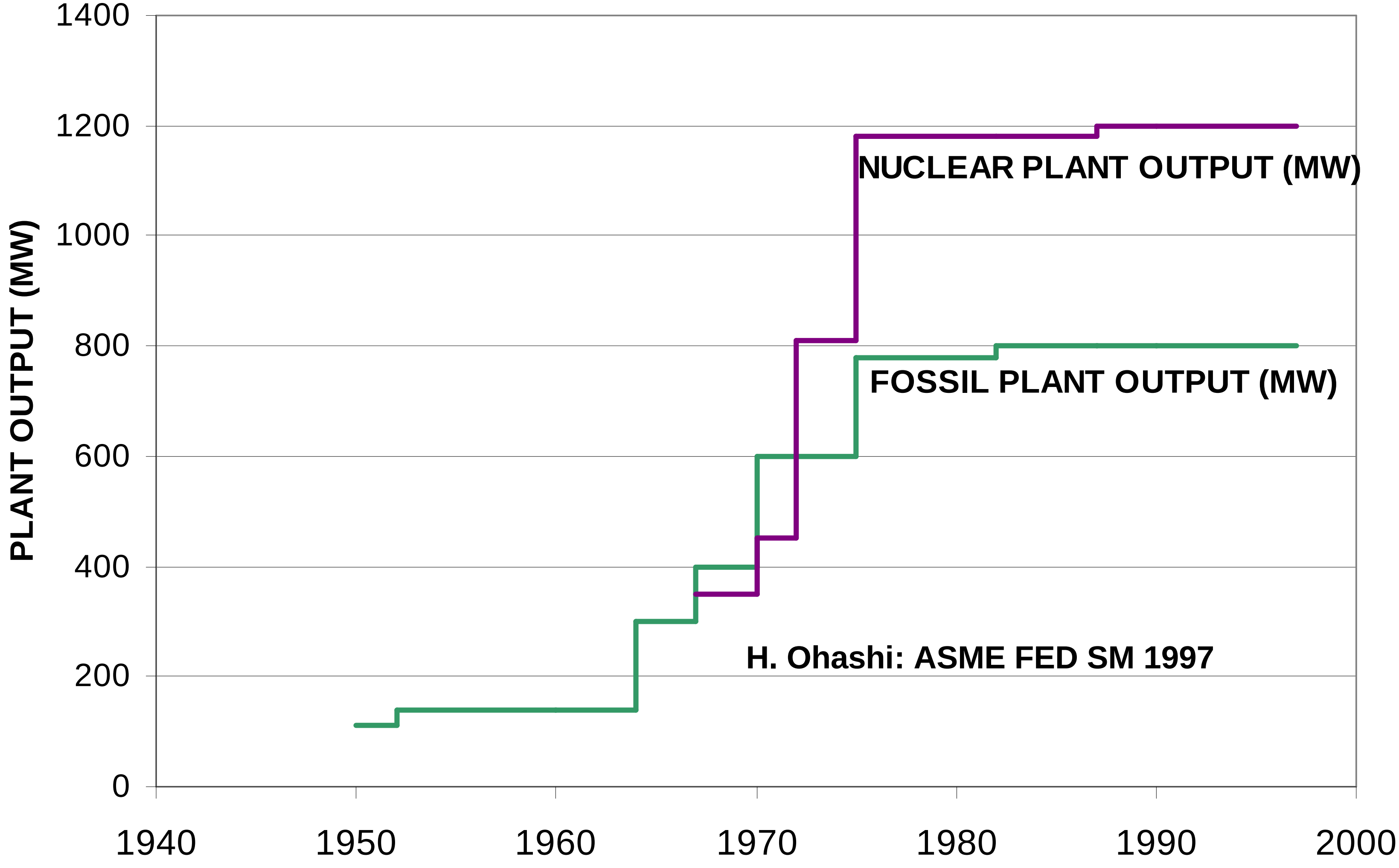
"LARGEST PUMP"

- LARGEST SIZE
  - Grand Coulee Dam on the Columbia River
  - Single Stage Vertical Volute Pump
  - 605,000 GPM, 330 ft TDH, 200 RPM
  - 55,200 HP
  - **Volute "Diameter" ~ 21 ft**
  - 1951

POWER PLANT DEVELOPMENT



POWER PLANT DEVELOPMENT



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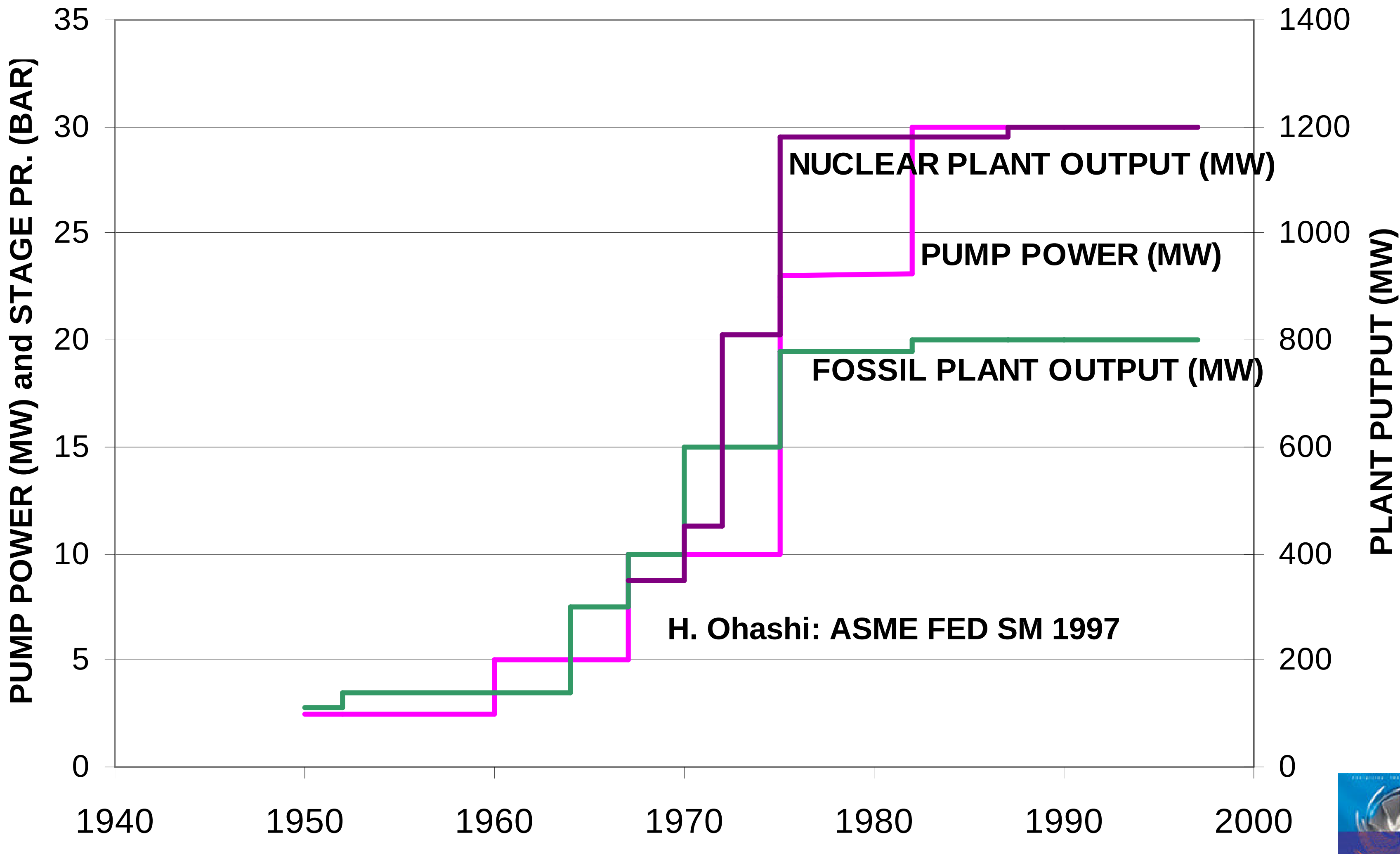
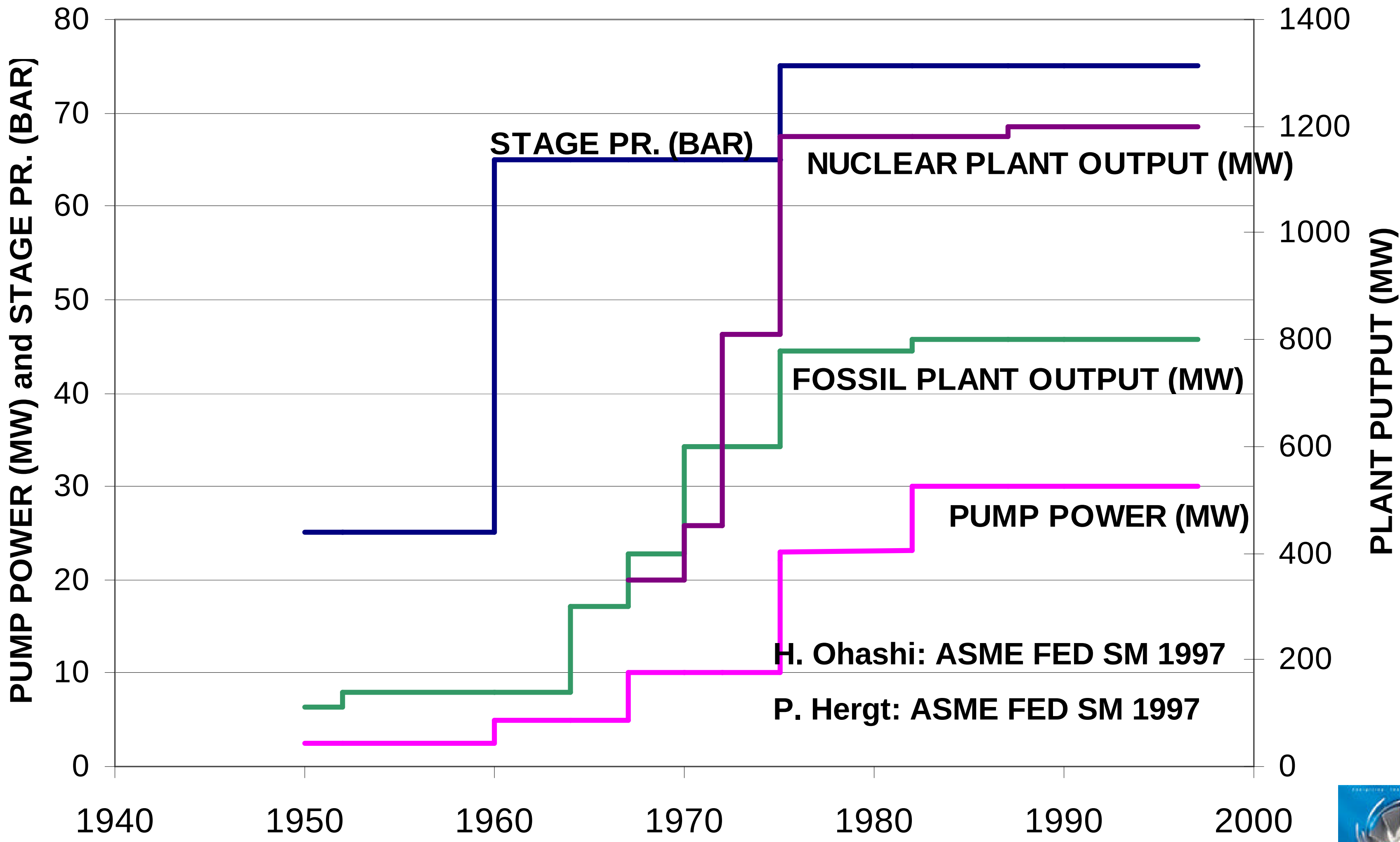
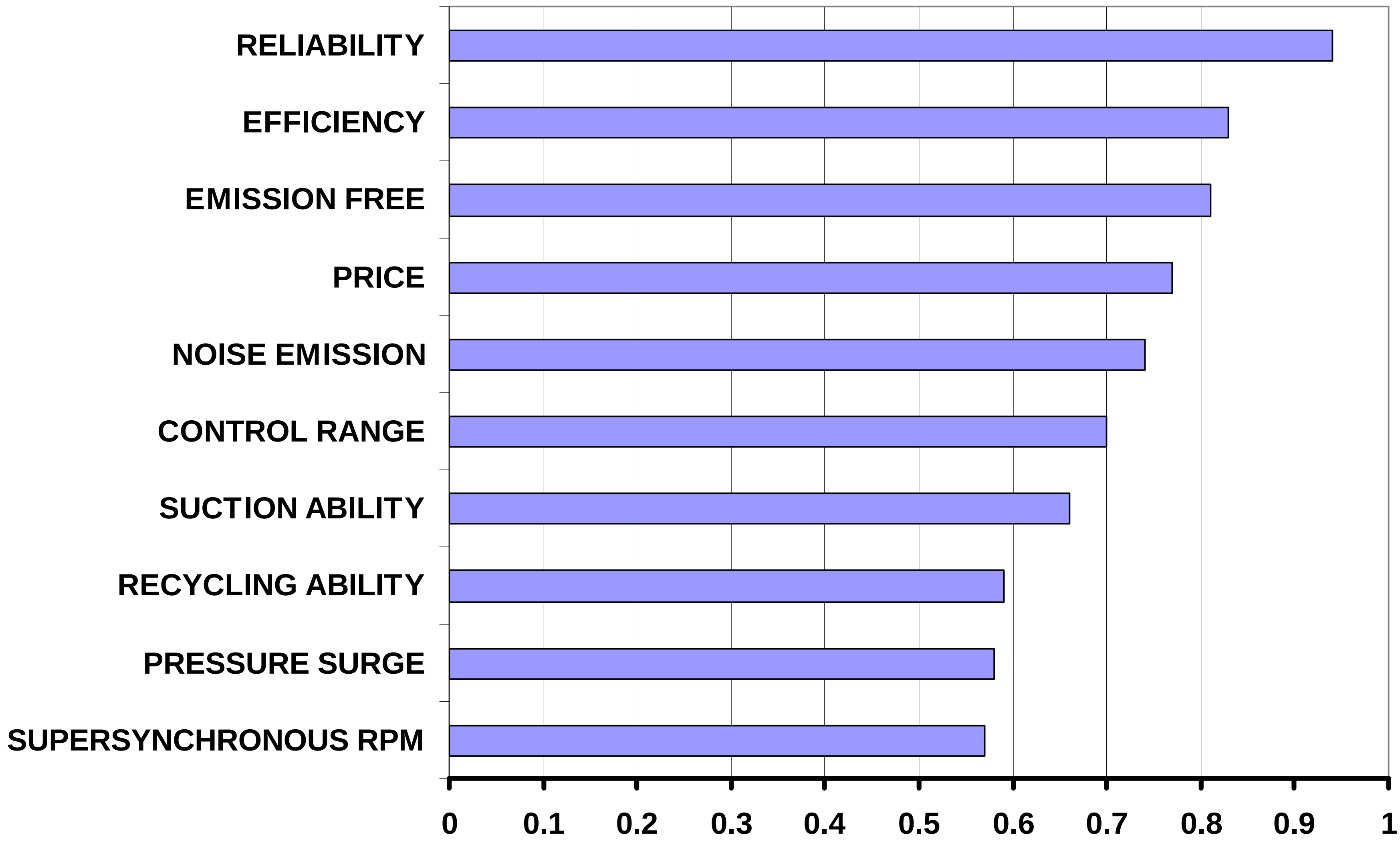


POWER PLANT DEVELOPMENT



CUSTOMER REQUIREMENTS

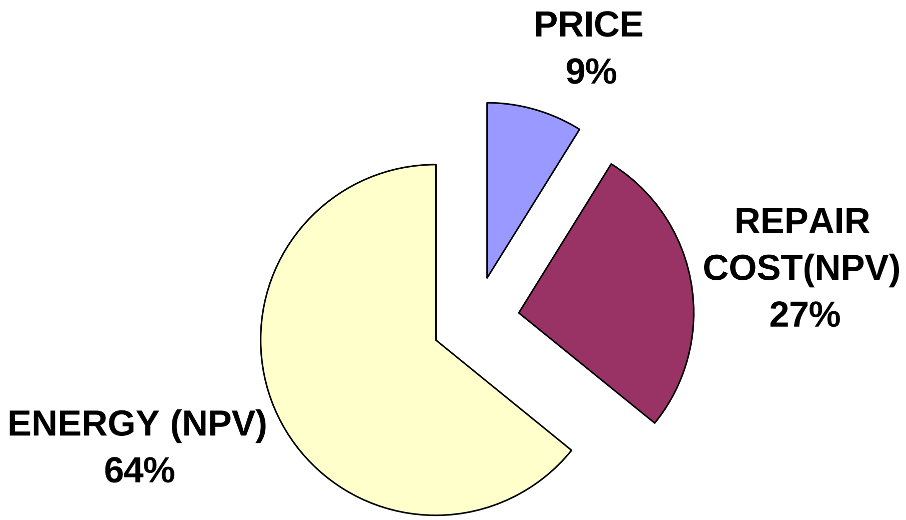


P. Hergt: ASME FED SM 1997

ECONOMICS OF RELIABILITY

- The cost of maintaining a pump significantly exceeds the first cost.

COST OF RELIABILITY

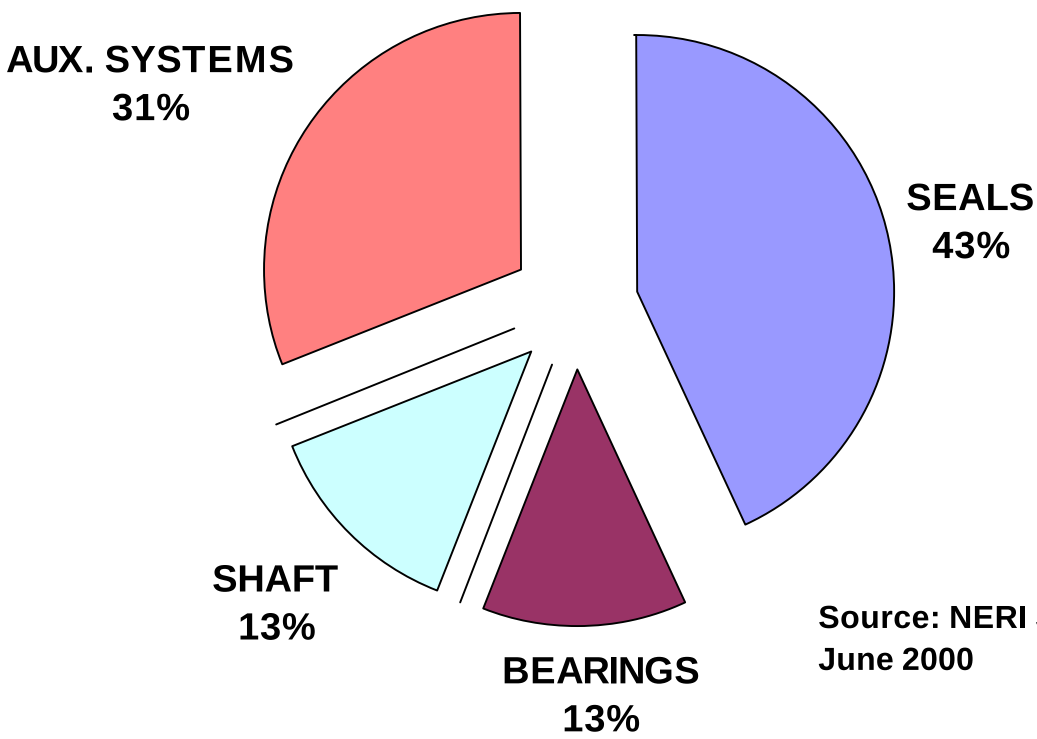


ANSI PUMP

ECONOMICS OF RELIABILITY

- The cost of maintaining a pump significantly exceeds the first cost.
- The imperative on the manufacturer is to increase MTBR.

CHARGE PUMP FAILURE DATA

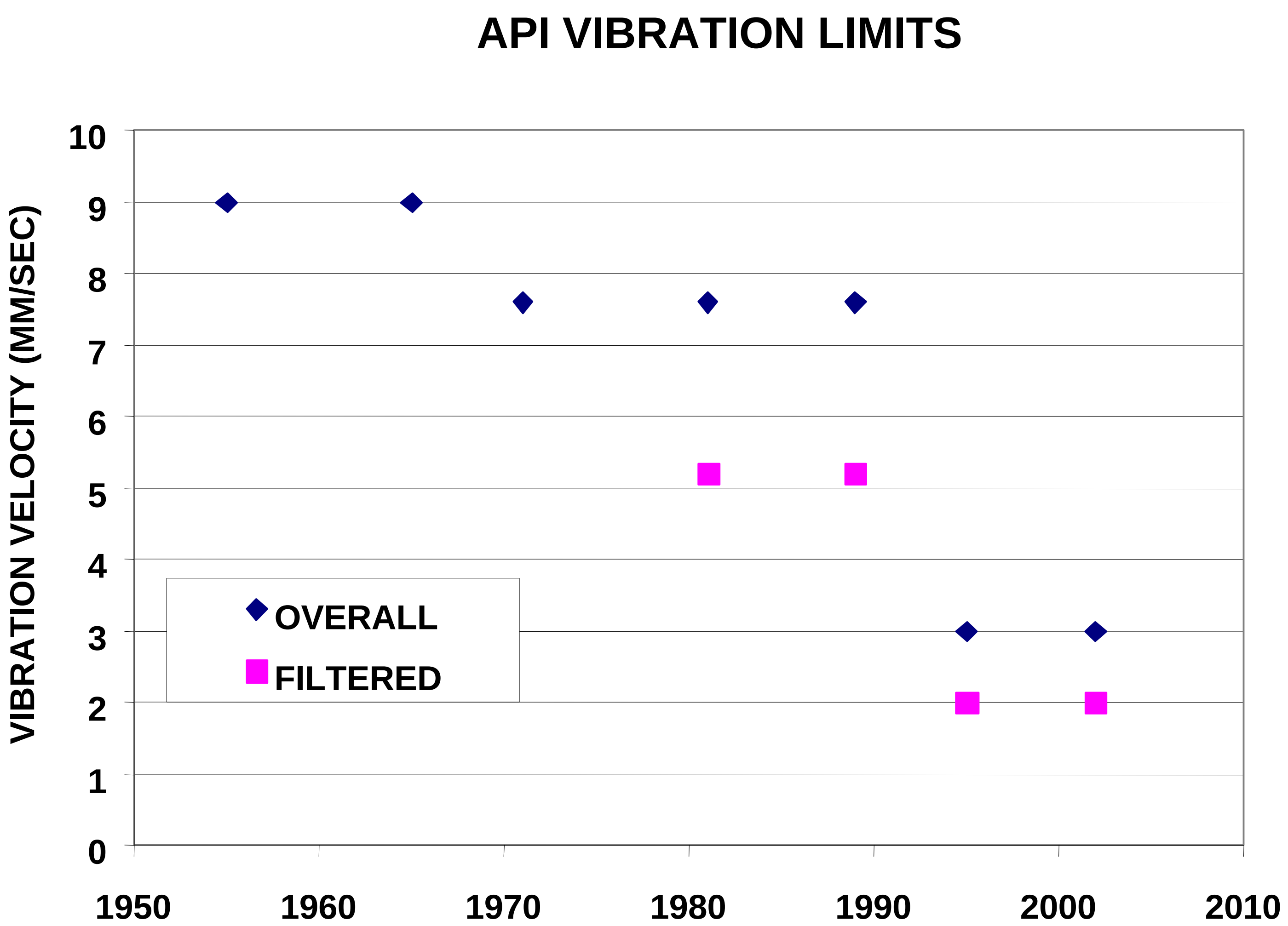


Source: NERI Smart NPP report Task 1
June 2000

RELIABILITY IMPROVEMENT INITIATIVES

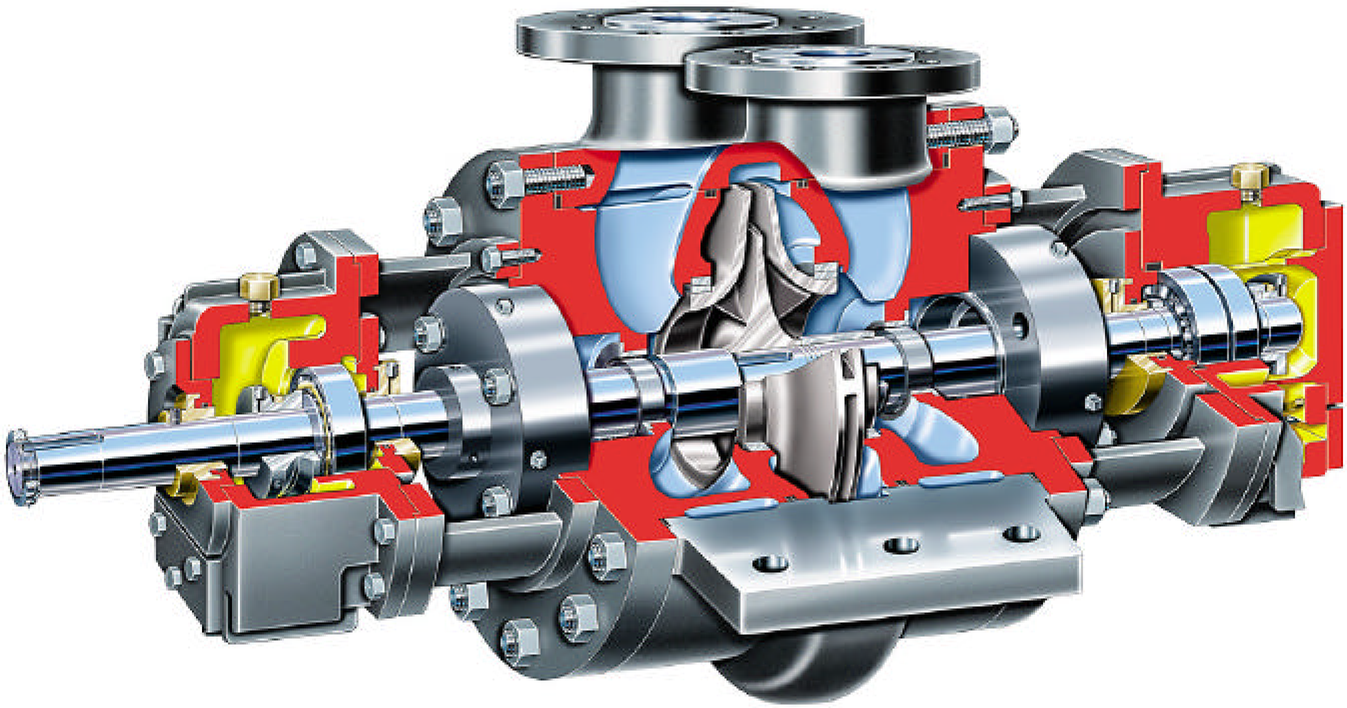
- ROBUST MECHANICAL DESIGN
  - Minimizing Vibrations
    - Reduction of Forces
    - Elimination of resonances
  - Improving cavitation resistance

RELIABILITY IMPROVEMENT



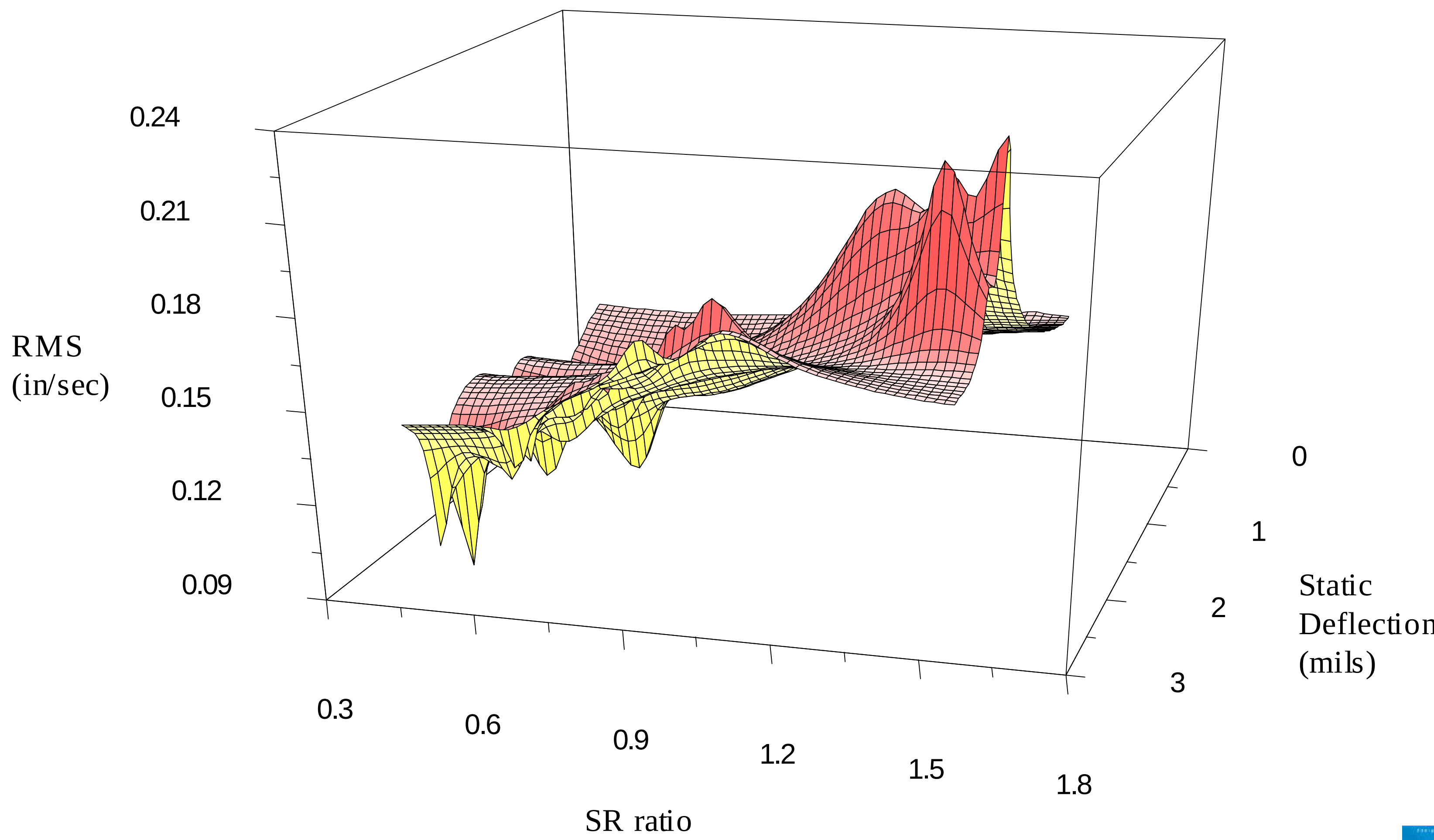
RELIABILITY IMPROVEMENT

DSHF



Double Suction Process Pump

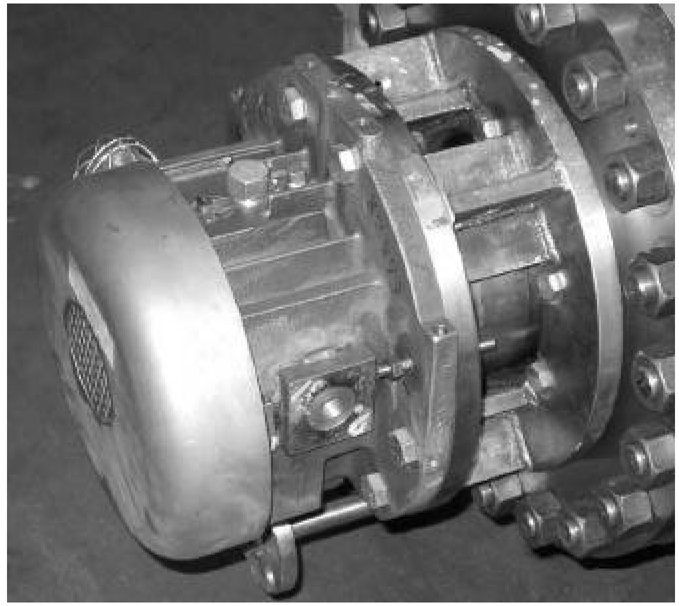
Vibration Data Map

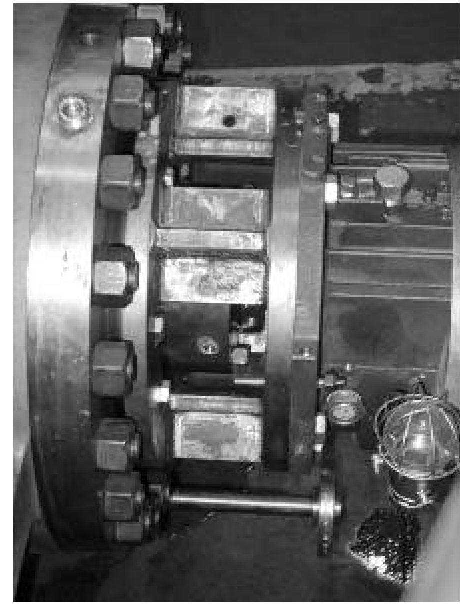


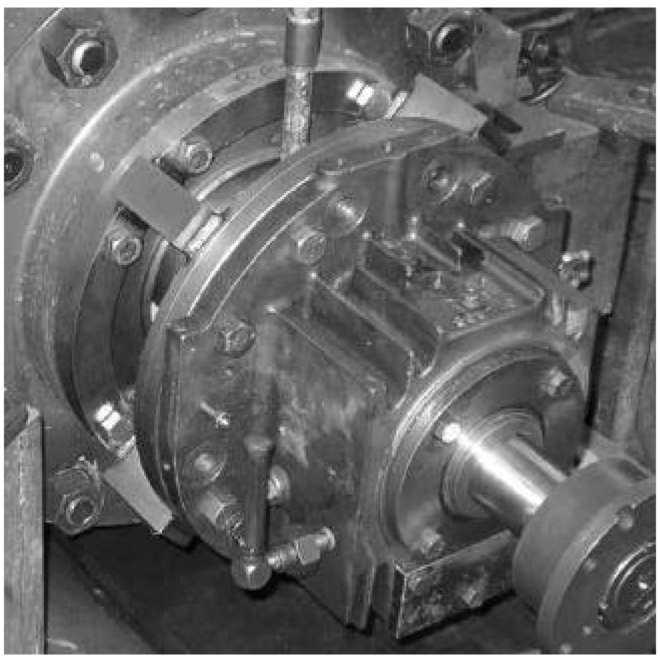
RELIABILITY IMPROVEMENT

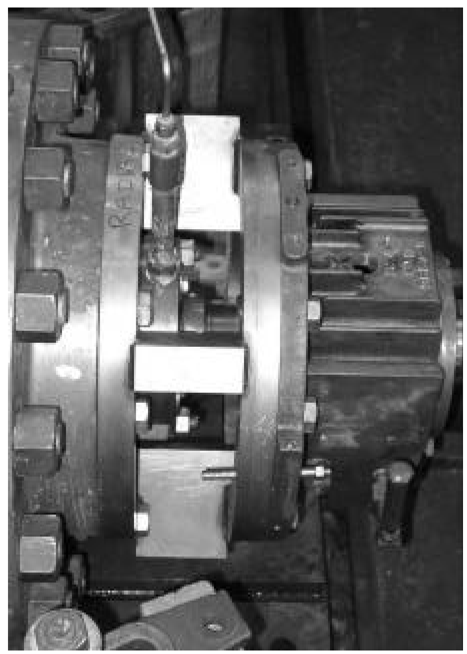
- Increase foot thickness
- Decrease bearing span
- Robust bearing adaptors

EXISTING DSHF BEARING ADAPTER DESIGN





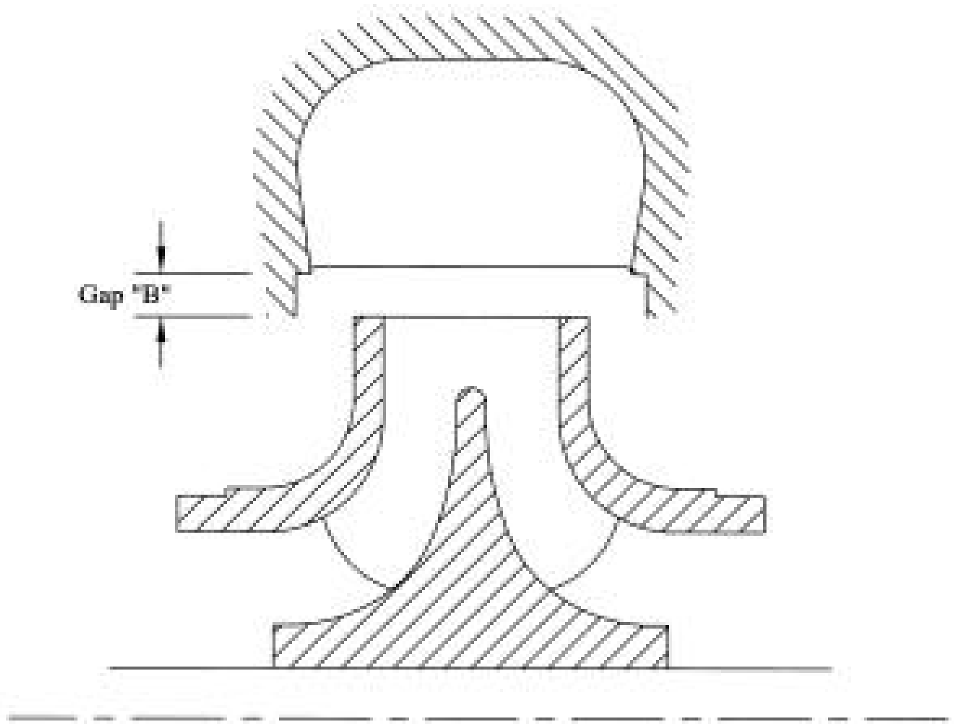




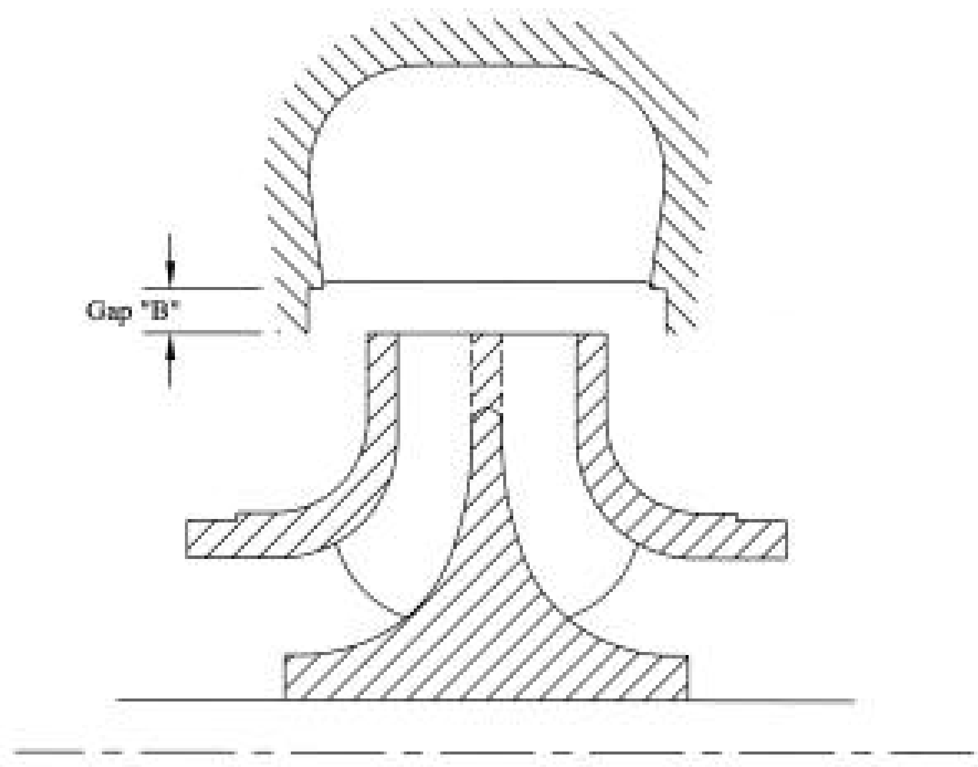
NEW DSHF BEARING ADAPTER DESIGN

FLOWSERVE

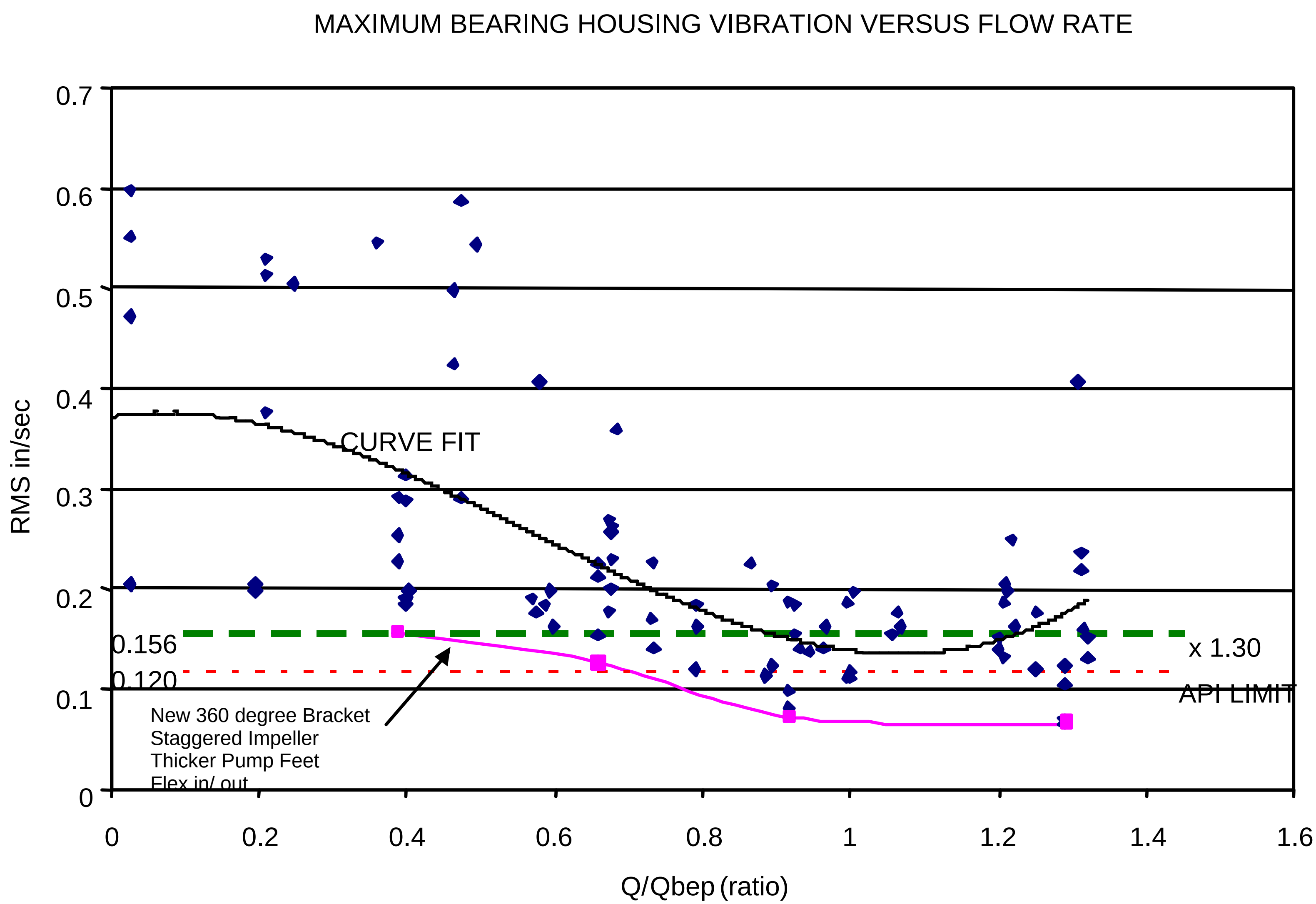
INCREASE OF GAP "B"



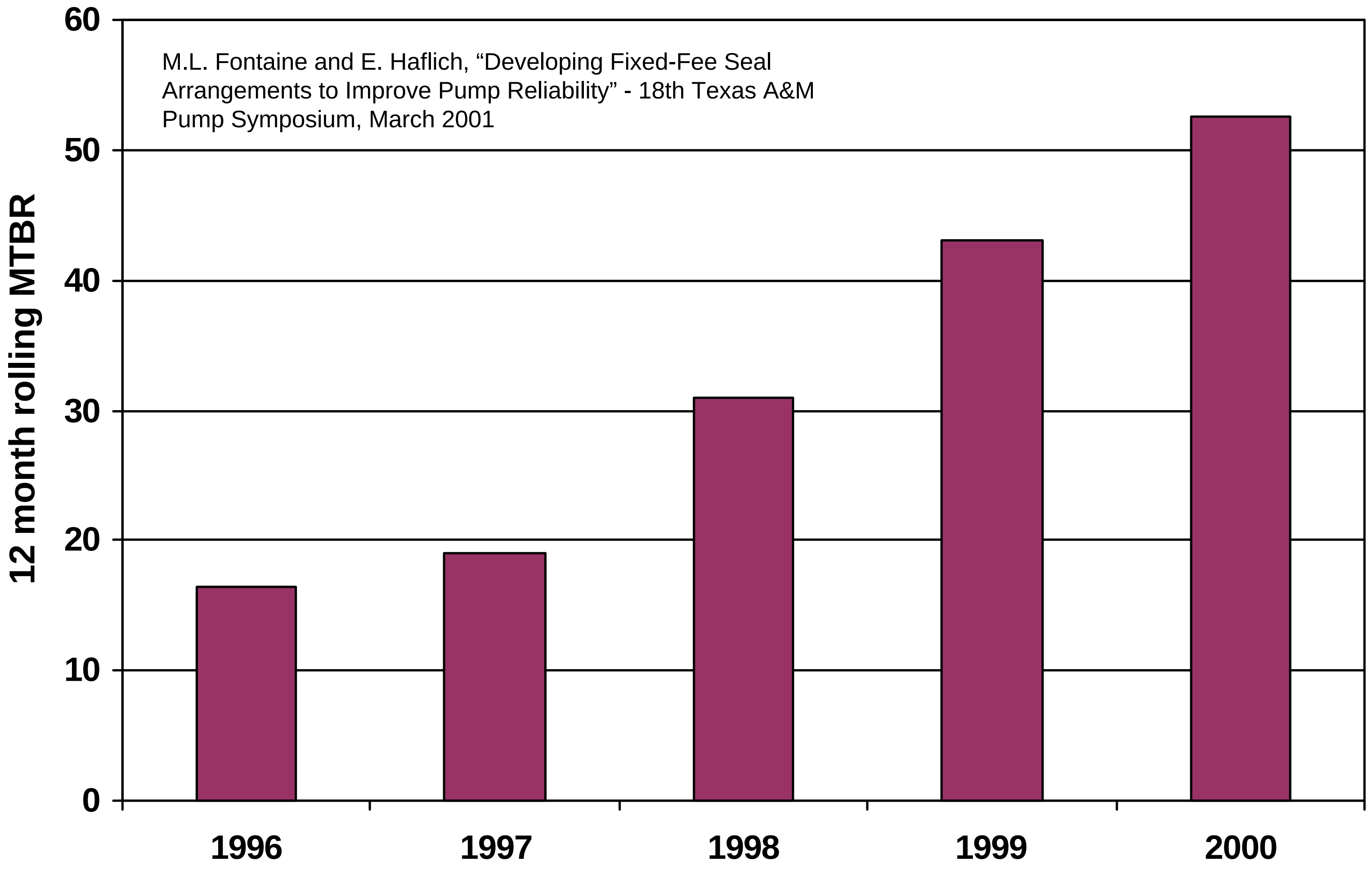
IMPELLER VANE STAGGER



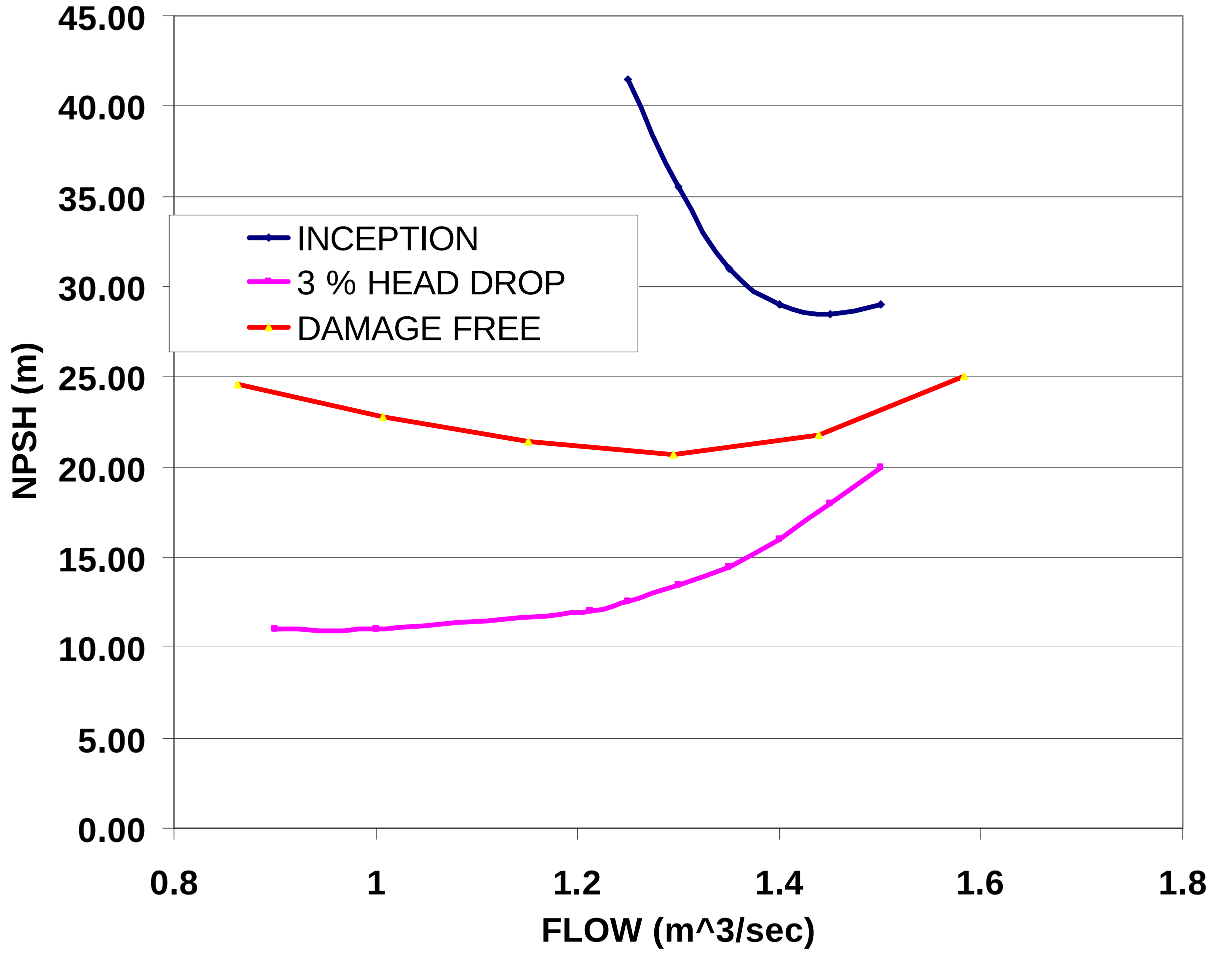
DSHF Pump Vibration Data



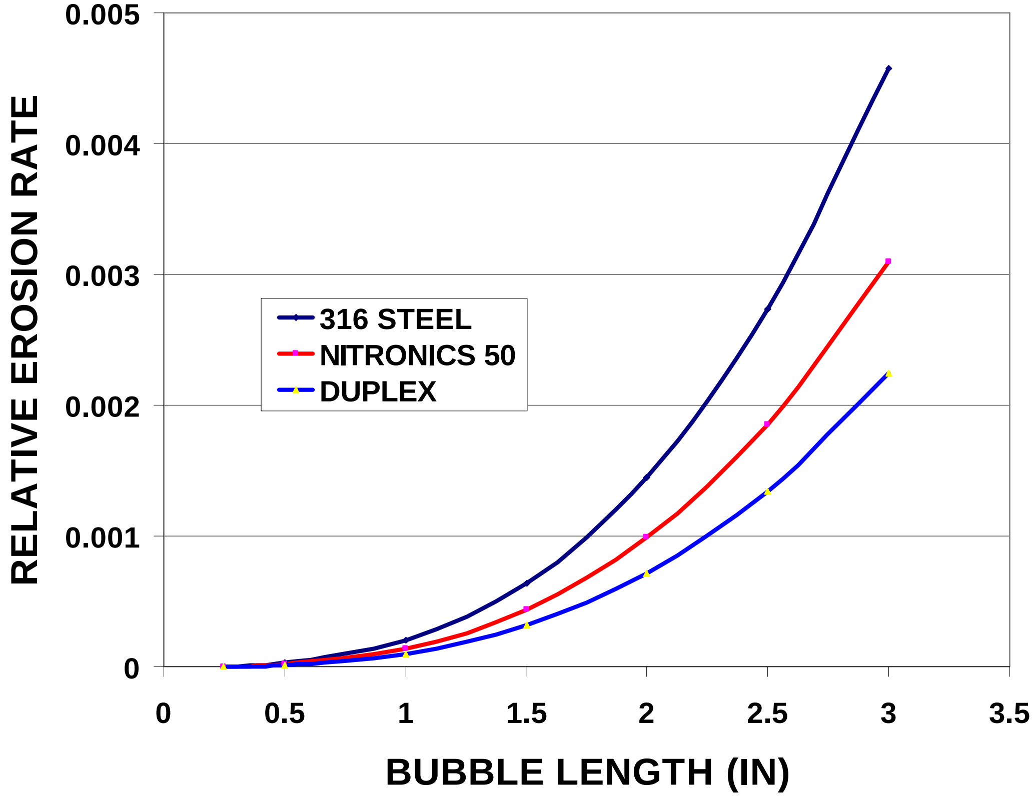
RELIABILITY IMPROVEMENT



NPSH REQUIRED



REDUCTION OF CAVITATION DAMAGE



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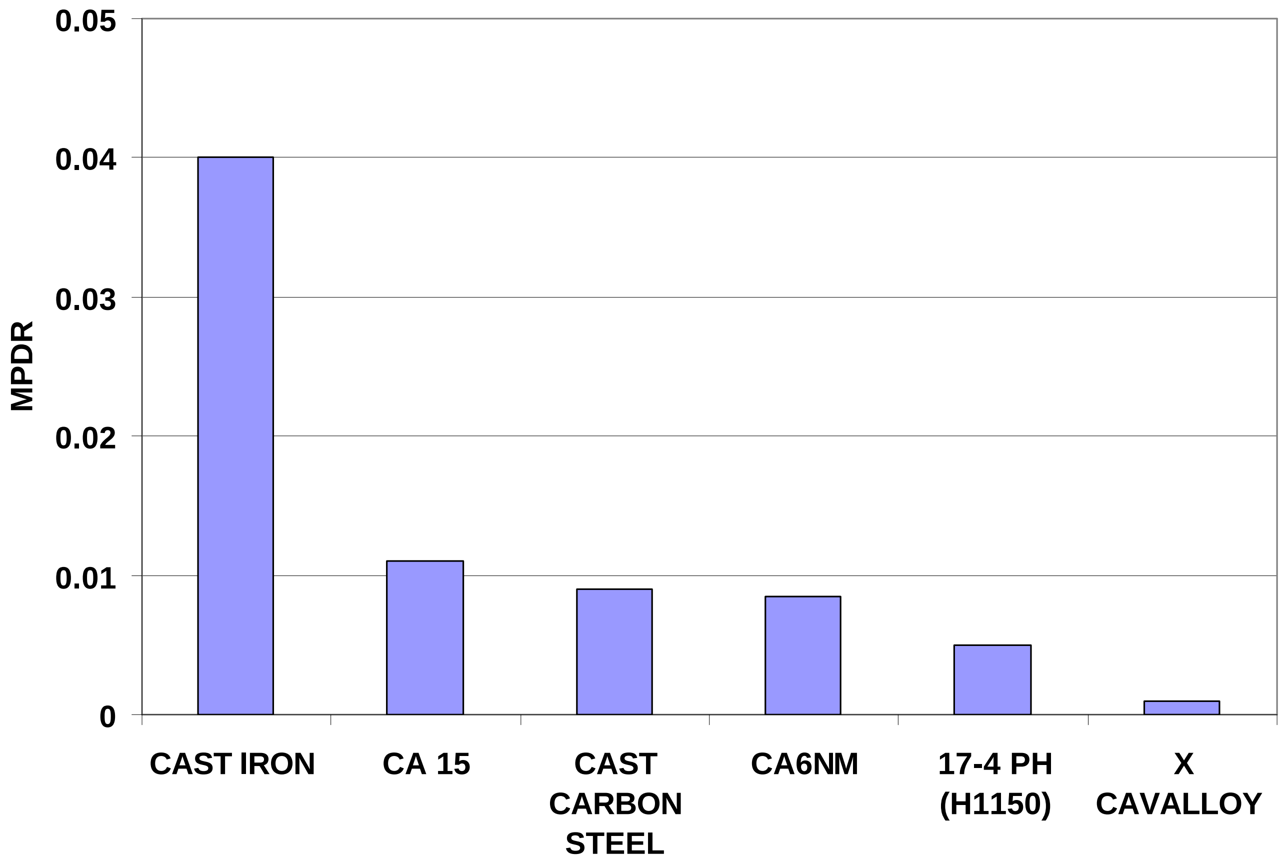
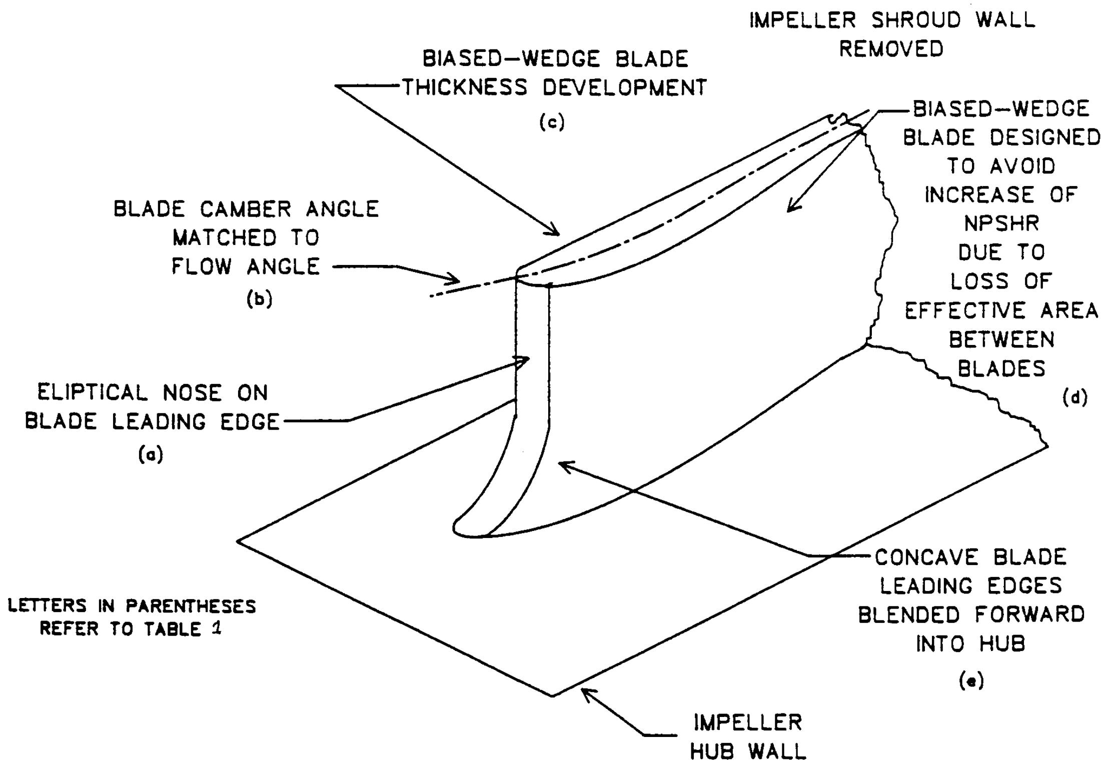


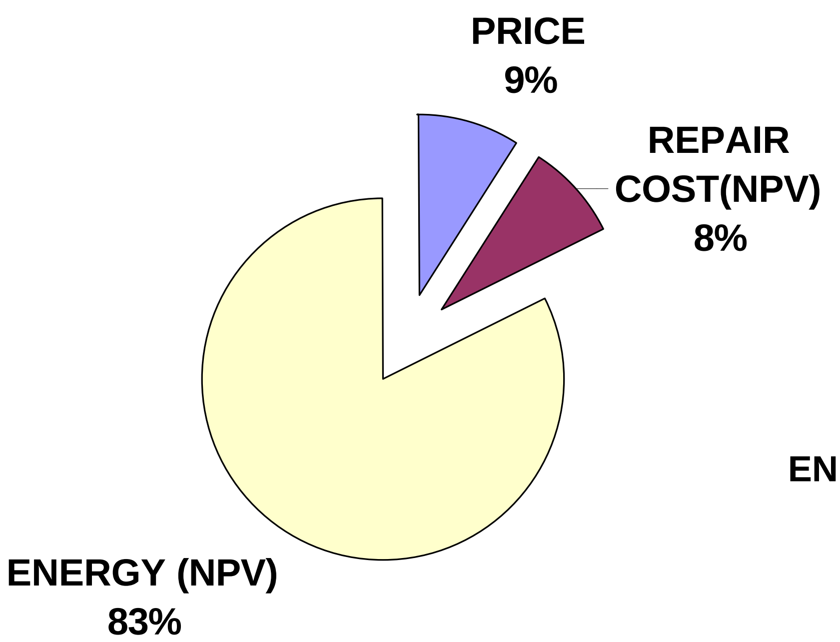
REDUCTION OF CAVITATION DAMAGE



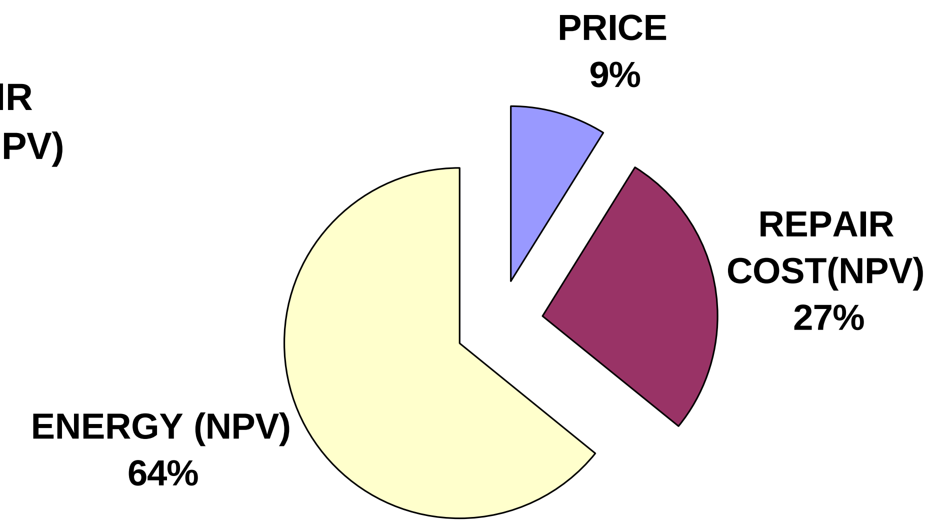
REDUCTION OF CAVITATION DAMAGE

- We still need a way to assess damage potential at factory testing stage.

ECONOMICS OF EFFICIENCY



API PUMP



ANSI PUMP

ENERGY COST CALCULATION MODEL

$$C_e = \sum_{j=1}^{Z} \left\{ n \cdot \frac{E_o}{[\mathbf{1}+\mathbf{r}]^{\mathbf{n}}} \cdot ? \cdot g \cdot \int_{t_0}^{t_1} \frac{Q(t) \cdot H(t)}{?_p \cdot ?_m} dt \right\}_j$$

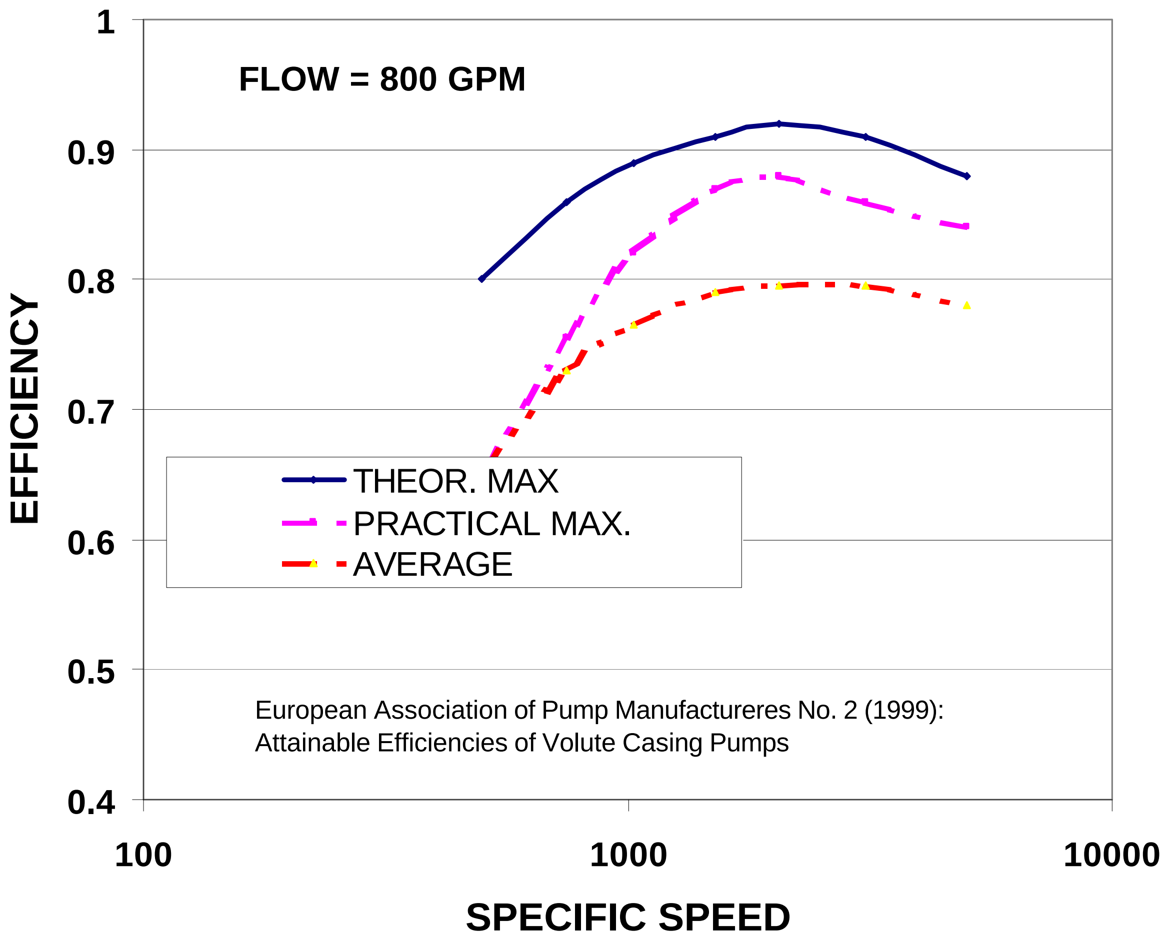
1. Power in one annual cycle
2. Cost of energy
3. No. of years
4. **Net present value**

Source: P. Wurzburger, “Energy - A basic element of Life Cycle Costing” - Einfúhrungsvortrag, Pump Users International Forum - Karlsruhe - October 2000

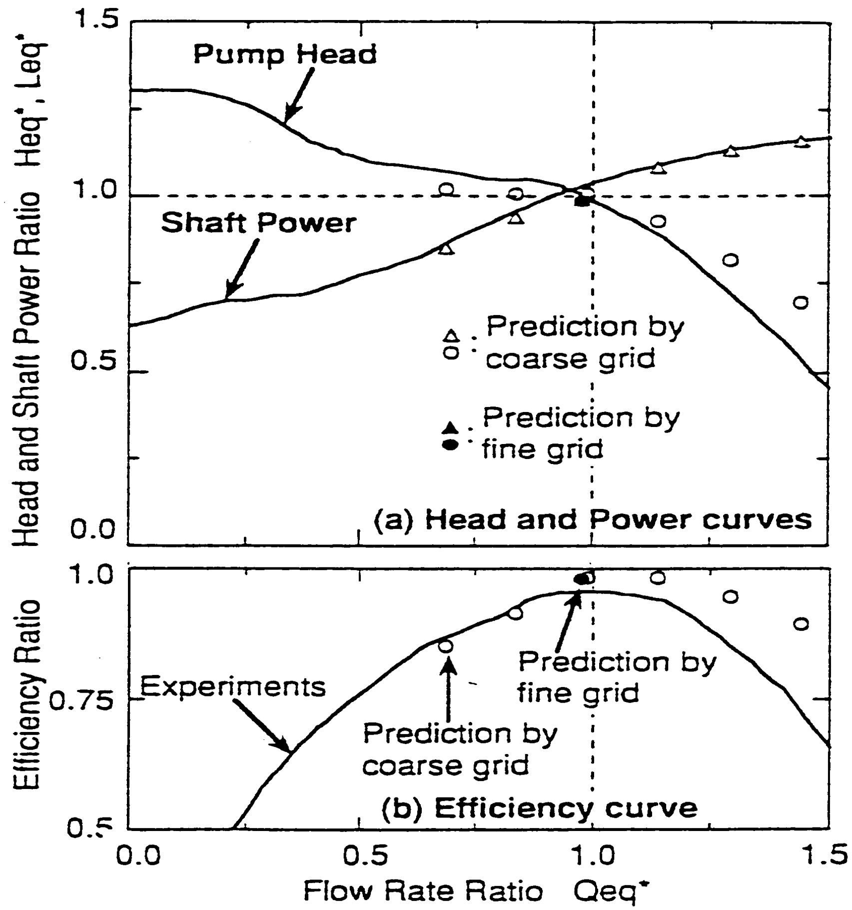
ECONOMICS OF EFFICIENCY

- A project funded by the European Commission (SAVE) has concluded:
  - Pump efficiencies can be improved with present technology by 3 points.
  - If all EU pumps are upgraded, a total of 1.1 TWhr of energy can be saved. At 5 c/kWhr, this amounts to about 50 million $ saving per year
  - Basic infrastructure issues are the impediment to this upgrade.

THEORETICAL EFFICIENCY



BASELINING WITH CFD



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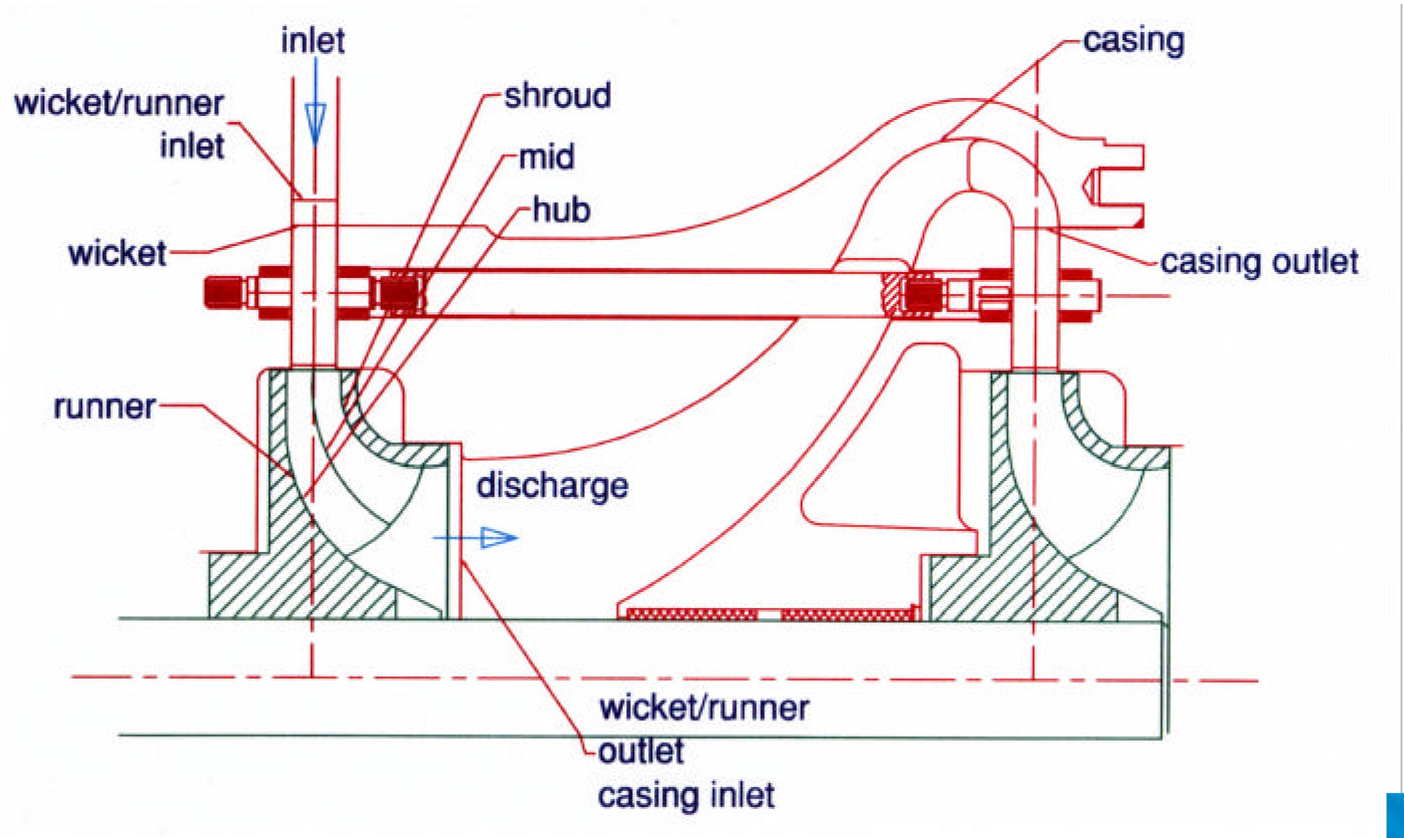
CRYOGENIC EXPANDER

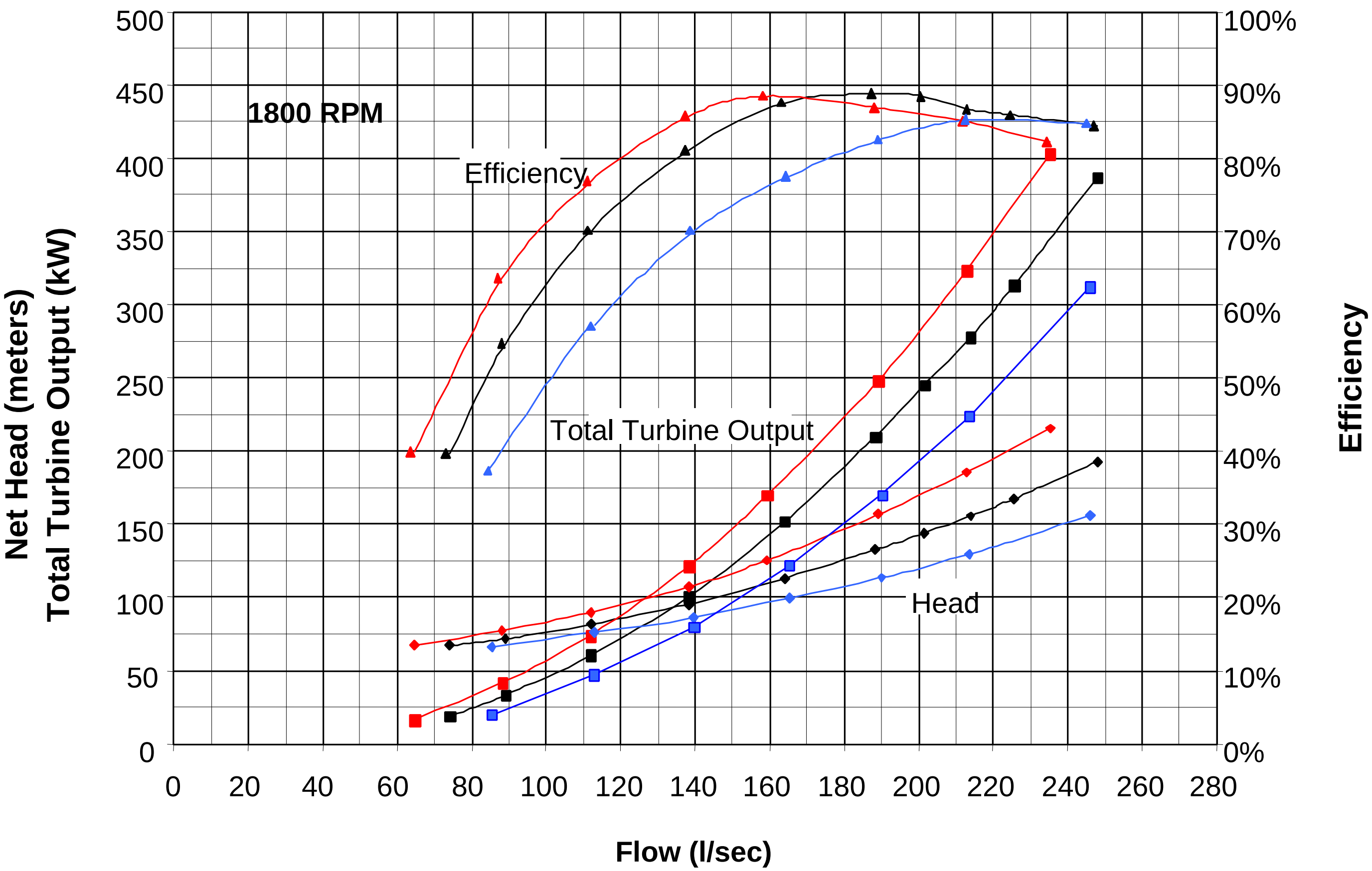


EFFICIENCY IMPROVEMENT

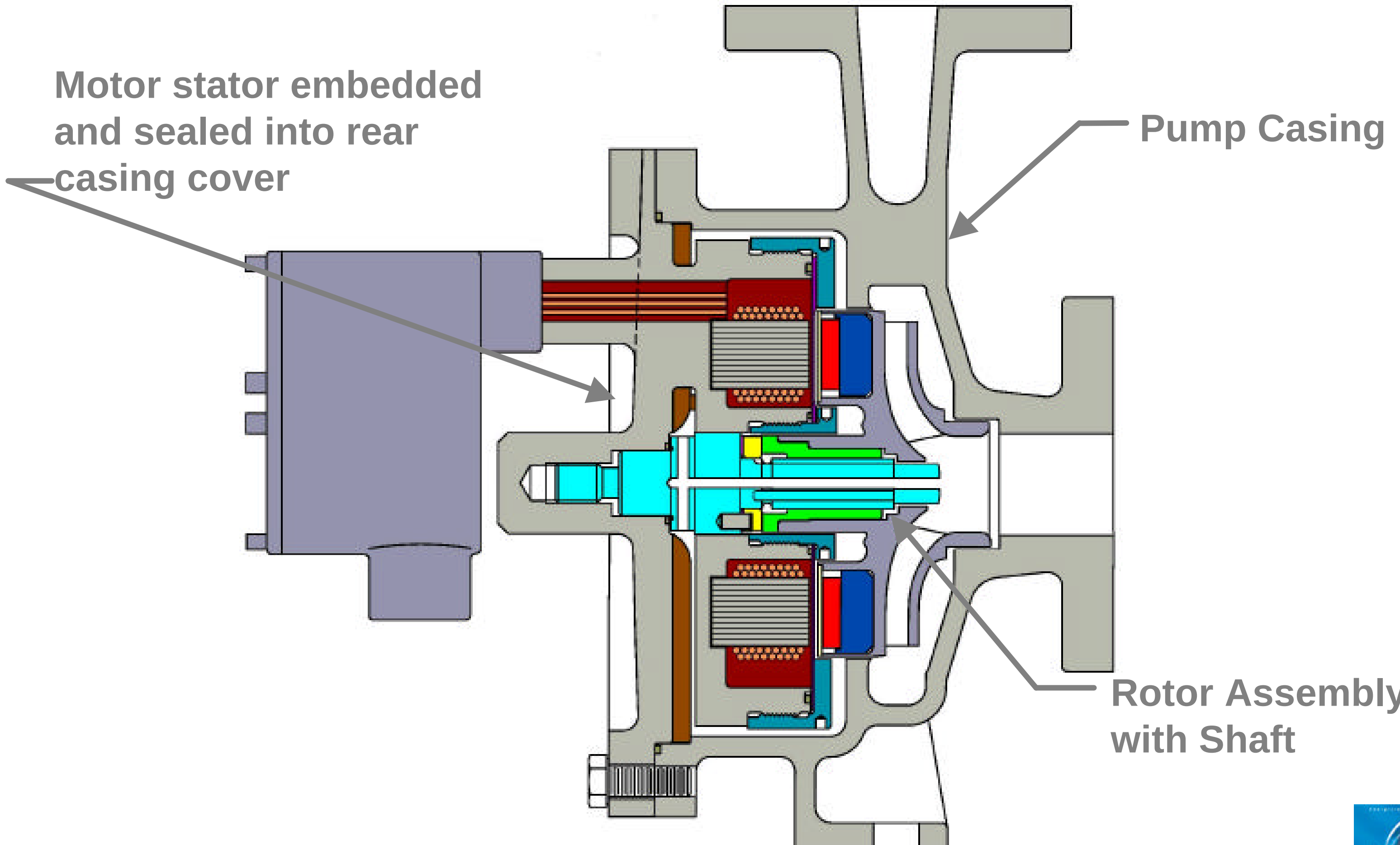
CALCULATED EFFICIENCES (%)

	SINGLE STAGE		MULTI-STAGE
	Hydraulic	Net	
8RL (Baseline)	92.1	89.2	85.0
8RH – Design #1	91.7	86.8	84.9
8RH – Design #2	94.5	89.6	87.9
8RH - Final	94.6	89.7	88.1

HIGH PERFORMANCE EXPANDER



ASSEMBLY OF SCAMP



CONCLUSIONS

- Pump Technology is driven by customer requirements
  - Reliability: Significant improvements in MTBR
  - Efficiency: CFD techniques are producing good results
  - Emission: Novel mechanical designs are being introduced