European Guide to

Pump Efficiency for Single Stage Centrifugal Pumps

Purpose of the Guide

This guide is for anyone wishing to buy or select pumps and save money. The aim is to help you choose a pump of good efficiency. This will reduce your energy costs. In some cases the saving from just one additional point of efficiency can pay for your pump. We hope this Guide will also reduce the energy used across the EU, benefiting everyone through a better environment.

Pump types and duties

This Guide should only be used for single stage centrifugal pumps handling clean water at up to 95°C. Pump types covered are:

- End suction pumps having their own bearings.
- End suction close coupled pumps, with the impeller on the motor shaft.
- Double entry pumps having an axially split casing.

The applicable ranges of flow and head are shown on Figs 1 and 2 for pumps running at nominally 2900 and 1450 rpm.

Figure 1: *Range coverage at best-efficiency duties at 2900 rpm.*

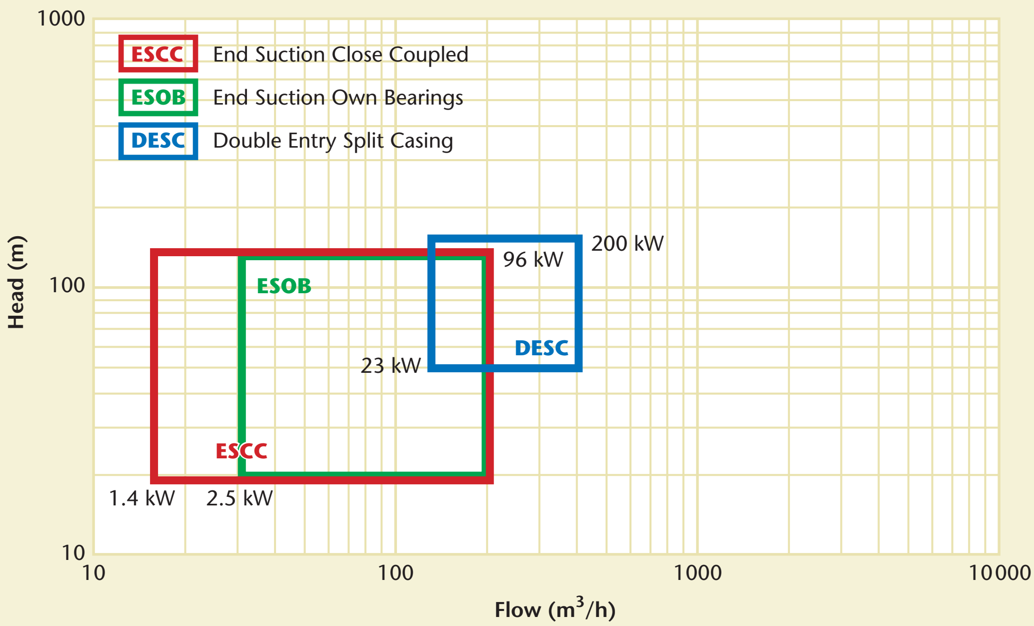
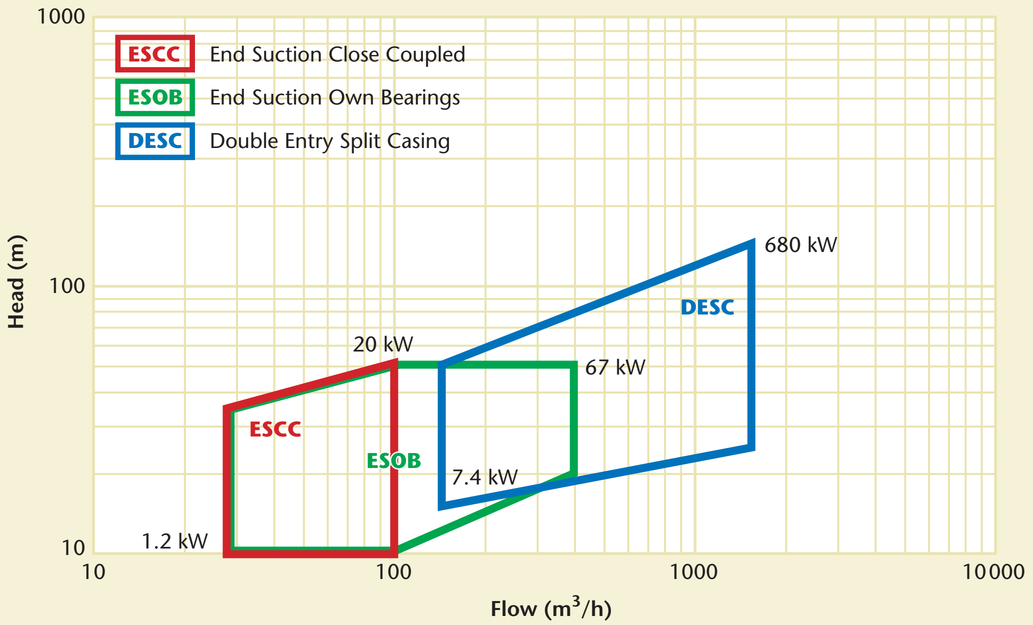


Figure 2: *Range coverage at best-efficiency duties at 1450 rpm.*



Method used for producing the efficiency plots

Performance curves published in manufacturers' catalogues have been used to produce six plots (Figs 3 to 8). The upper pump efficiency line on each plot shows the 'Catalogue mean of best-efficiency points' at maximum impeller diameter, after correcting for pump head.

The lower line is an average of efficiencies for pumps typically selected for flows across the range, which are not always operating at best efficiency point or maximum impeller diameter *(Ref 1)*.

The two lines divide the plot into three areas:

- **Optimum efficiency selections**: high efficiency pumps operating at or close to the best efficiency point
- **Efficient selections**: pumps which probably have a reasonable best efficiency but, because of standard pump ranges, may have been quoted away from BEP (Best Efficiency Point)
- **Lower efficiency selections**: selection in this area should only be accepted if other parameters override (such as very low NPSH, pump operating with short run times, spares inventory minimisation)

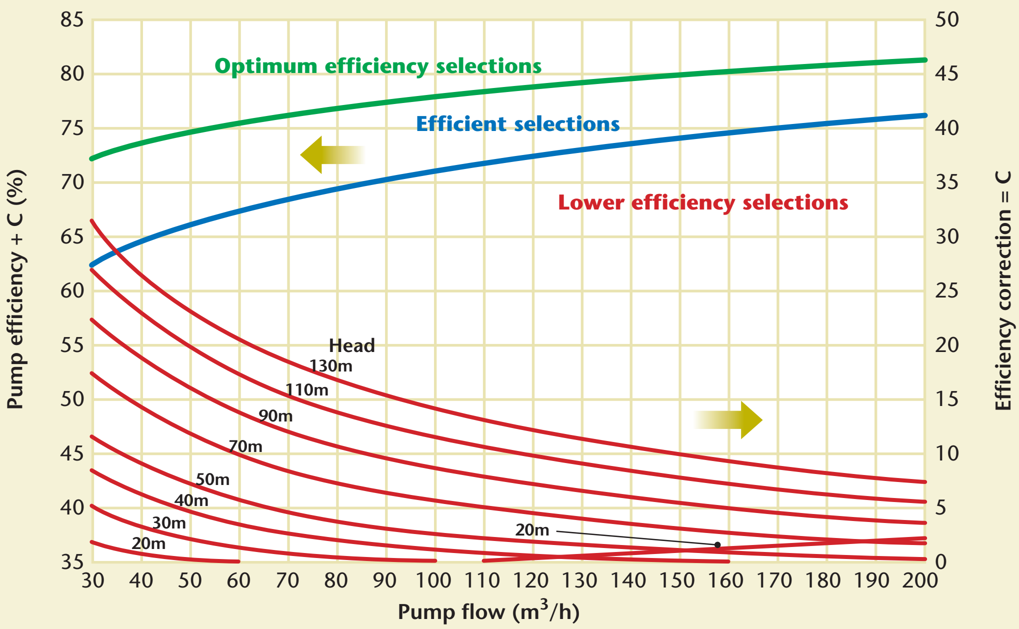


Figure 3: *Efficiencies of end suction pumps with their own bearings at 2900 rpm.*

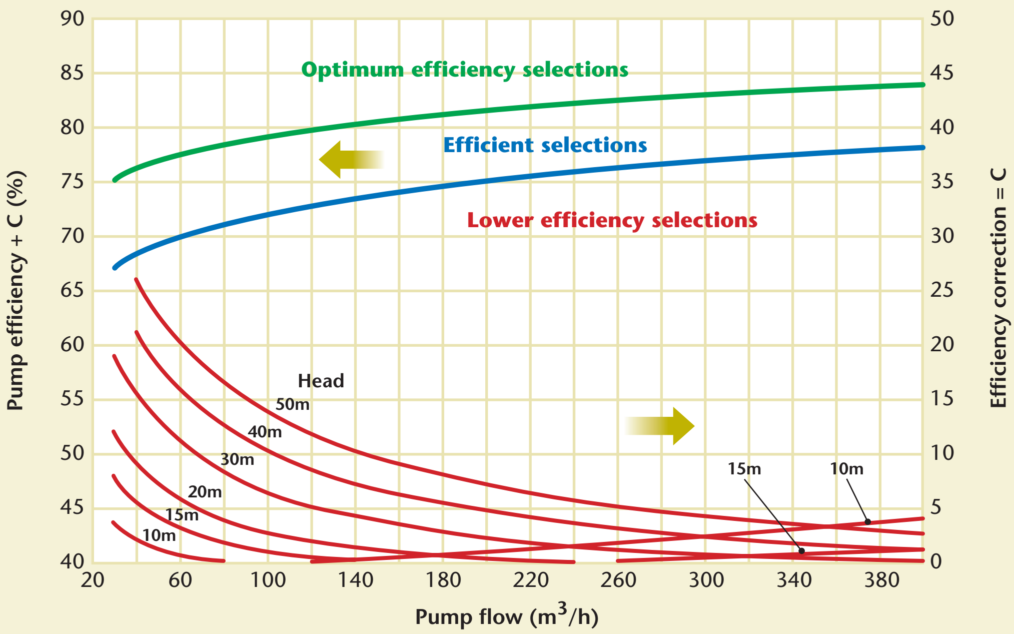


Figure 4: *Efficiencies of end suction pumps with their own bearings at 1450 rpm.*

How to use the efficiency plots:

1. Decide which type of pump you want.
2. Choose the flow and head at which you would like maximum efficiency.
3. Get efficiency quotes from manufacturers (or use published information).
4. Check that the chosen flow and head are within the ranges of Figs 1 or 2.
5. Enter your chosen flow and head on the plot that suits the quotes (Figs 3 to 8).
6. Read correction factor 'C' on the right-hand axis.
7. Add 'C' to the efficiency that has been quoted.
8. Plot (quoted pump efficiency + correction 'C') at your chosen flow.

If the point lies in the **'Lower efficiency selections'** area, seek higher efficiency quotes.

If the point lies in the **'Efficient selections'** area, you have a pump which may well have a reasonable best efficiency but, because of standard pump ranges, has been quoted away from BEP. You should therefore seek higher efficiency quotes, to see if you can get a pump with the BEP closer to your operating point.

If the point lies in the **'Optimum efficiency selections'** area, you have been quoted a pump with high best efficiency and you are operating close to BEP and you are unlikely to improve on this selection.

Figure 5:
Efficiencies of end suction close coupled pumps at 2900 rpm.

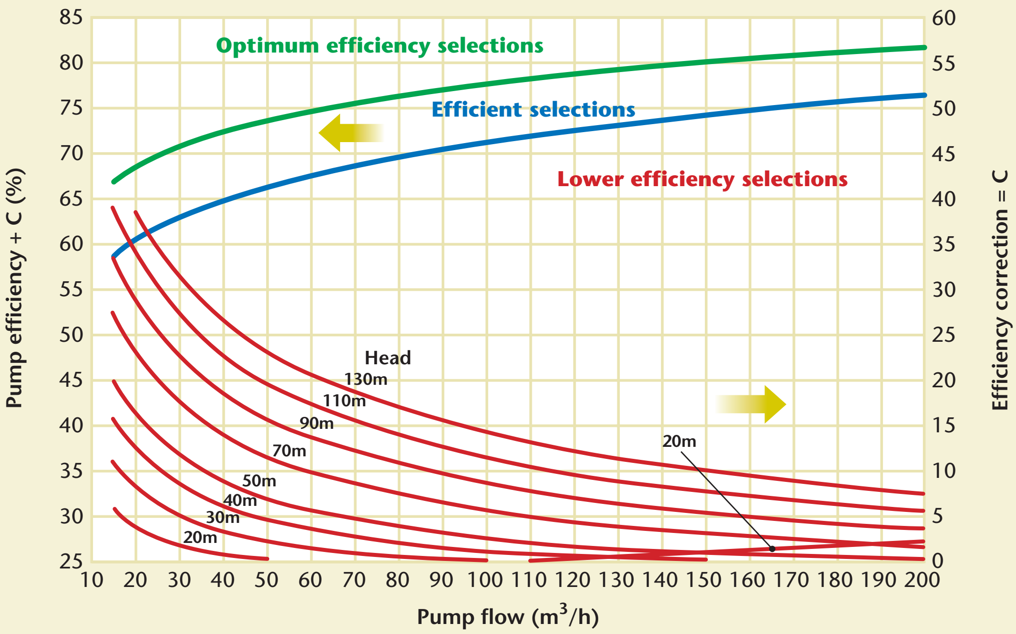
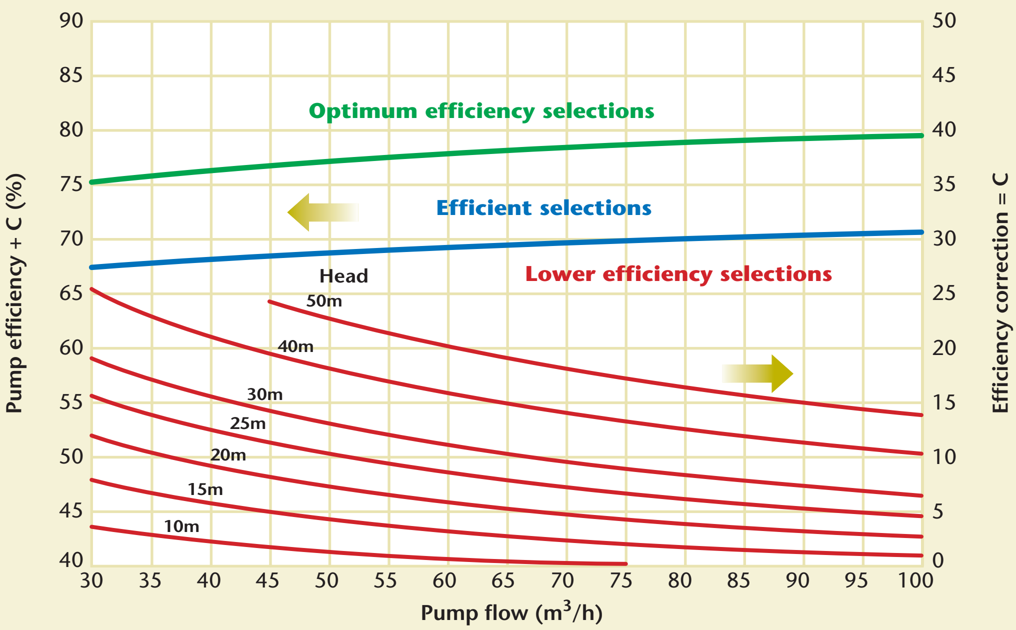


Figure 6:
Efficiencies of end suction close coupled pumps at 1450 rpm.



Important note: *Although a quoted low efficiency may be due to poor pump quality, it is more likely to be due to your chosen duty not coinciding with that pump's best-efficiency point. Your flow may be below or above the optimum for that pump. Your head will probably require a reduced diameter impeller. A survey has suggested that you are unlikely to receive more than one quote in five in the* ***'Optimum efficiency selections'*** *area.*

Worked example:

Chosen pump type:	End suction with own bearings.
Chosen duty for maximum efficiency:	80 m^3/h at 110 m.
Quoted pump performance:	60% efficiency at 2900 rpm. (Check materials, suction performance, etc, are satisfactory)
Is chosen duty within ranges covered:	From Fig 1, yes. From Fig 3: 'C' = 14. Plot on Fig 3: 'Pump Efficiency + C' = 60 + 14 = 74%. Fig 3 suggests that an additional 3 points of efficiency or more is possible.
Action:	Seek further quotes.

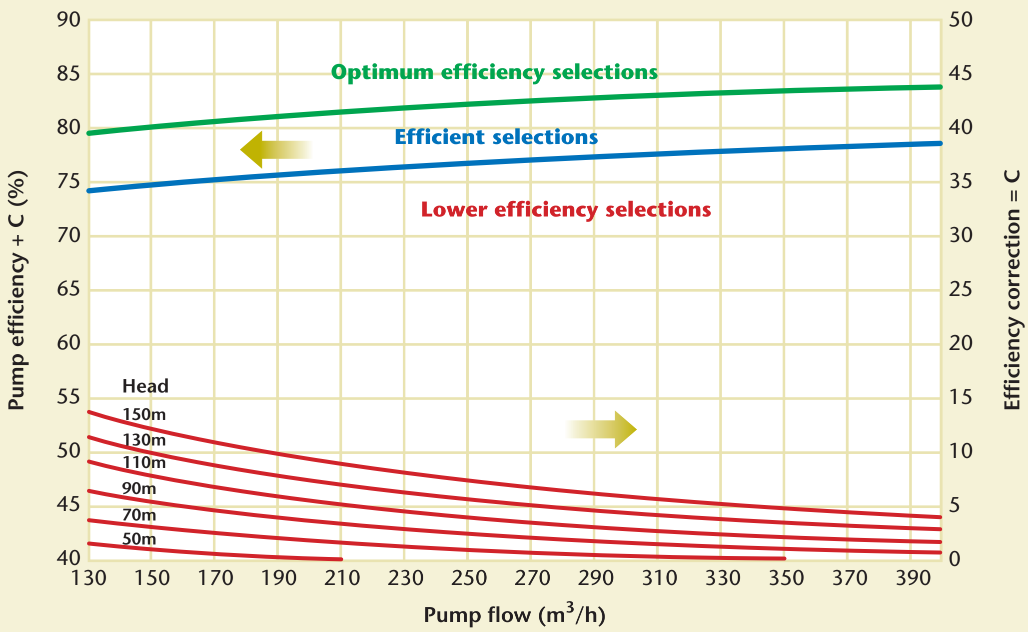


Figure 7: *Efficiencies of double entry axially split casing pumps at 2900 rpm.*

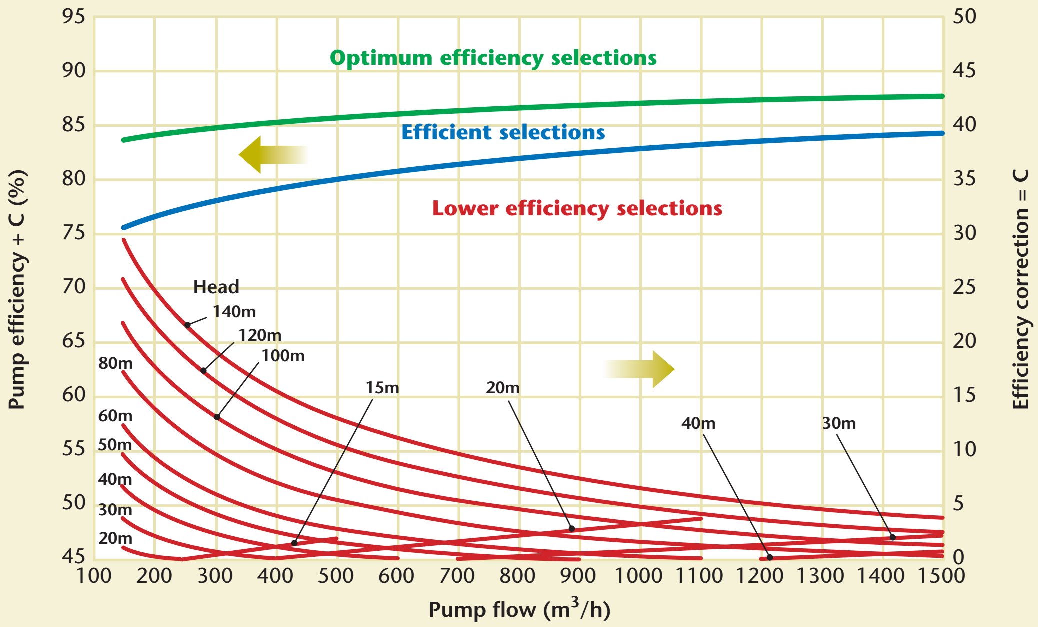


Figure 8: *Efficiencies of double entry axially split casing pumps at 1450 rpm.*

Correction of efficiency for pump head

Correction 'C', as shown on Figs 3 to 8, is based on pump flow, head and speed. It is actually a correction for pump Specific Speed. Pumps of relatively low head and high flow (high Specific Speed) or high head and low flow (low Specific Speed) lose efficiency due to unavoidable secondary hydraulic losses. Within *Ref 2* there is a curve to allow efficiency correction for Specific Speed. This is actually the correction proposed by Anderson (*Ref 3*). Alternative curves to correct for Specific Speed can be derived from *Ref 4* and *Ref 5*.

None of these curves appear to provide an 'optimum' correction for the published manufacturers' data analysed for this Guide. We have therefore chosen to use an intermediate Specific Speed correction curve, which produces the minimum scatter of the points plotted. There is no strict theoretical justification for this approach but we believe that it serves well for the purpose for which this Guide is intended. (Further information can be found in *Ref 6*.)

Loss of pump efficiency with time

A pump of high efficiency is of little value if the efficiency falls rapidly with time. You can minimise this risk. Choose materials carefully, particularly for wear rings. Avoid high and low flow operation in relation to your chosen duty. Ask for cast iron casings to be protectively coated if the water is known to cause serious roughening due to corrosion.

Life Cycle Cost (LCC)

It is likely that the design of the pumping system and the way the pump is operated will have a greater impact on the energy consumption than the pump efficiency alone. You should carry out an LCC analysis to compare different technical alternatives of designing, operating and maintaining a pumping system. The LCC represents the total expenses to purchase, install, operate, maintain and repair a pumping system during its projected life. Down time and environmental costs are also considered.

A well-documented guide has been published by Hydraulic Institute and Europump (*Ref 7*). The guide explains how the operating costs of a pumping system are influenced by system design, and shows in detail how to use an LCC analysis to estimate these costs. Using the recommendations of the guide, you should take into account not only the initial investment cost, but also all the other costs and expenses of operating the system during its projected life.

Basic principles of choosing a pump

The fundamentals of pump selection are covered in Appendix 3 of *Ref 6*, together with notes on the basics of centrifugal pump characteristics, reducing impeller diameter, reducing speed, and the effect of wear.

Efficiency plots used in this Guide compared to other sources

For practical reasons it has only been possible to source a limited amount of data to produce the plots in this Guide. To assess how meaningful the results are, it is useful to compare them with other sources. The best efficiencies (corrected to optimum Specific Speed) for end suction pumps having their own bearings at 2900 rpm are plotted in Fig 9. The mean of these points is marked **Catalogue 'mean'**. Additional curves (all at optimum Specific Speed) are derived as follows:

- **'Hydraulic Institute'**
  Fig 1A (*Ref 2*).
- **'Anderson'**
  Fig 7.3 (*Ref 3*).
- **'Maximum practically attainable'**
  (EUROPUMP) - Figs 7 to 10 (*Ref 4*).
- **'Theoretically attainable'**
  (EUROPUMP) - Using Figs 7 to 10 of Ref 4 (*Ref 5*).

From Fig 9 we deduce that the **Catalogue 'mean'** curve is suitable for use in this Guide. The **'Hydraulic Institute 'ANSI/API''** curve is low, particularly at low flows. This is probably mainly due to the use of relatively large wear ring clearances, as required for pumps in special materials or to meet the American Petroleum Institute (API) Standard.

References

1. *'Evaluation of efficiency values considering the effect of pump size modularity'*, Stoffel, B., Ludwig, G., and Meschkat, S., Technical University of Darmstadt, 2002.
2. *'Efficiency prediction method for centrifugal pumps'*, Hydraulic Institute, 1994.
3. *'Centrifugal pumps and allied machinery'*, Anderson, H.H., Elsevier Advanced Technology, 1994.
4. *'Attainable efficiencies of volute casing pumps'*, Europump Guide No. 2, 1999.
5. *'Theoretically attainable efficiency of centrifugal pumps'*, Stoffel, B. and Lauer, J., Summary of the final report on the research project for VDMA, Technical University of Darmstadt, 1994.
6. *'Study on improving the efficiency of pumps'*, Report produced for the European Commission – SAVE, 2001. Available via http://energyefficiency.jrc.cec.eu.int/motorchallenge
7. *'Pump life cycle costs: A guide to LCC analysis for pumping systems'*, Europump and Hydraulic Institute, 2000. (ISBN 1-880952-58-0)

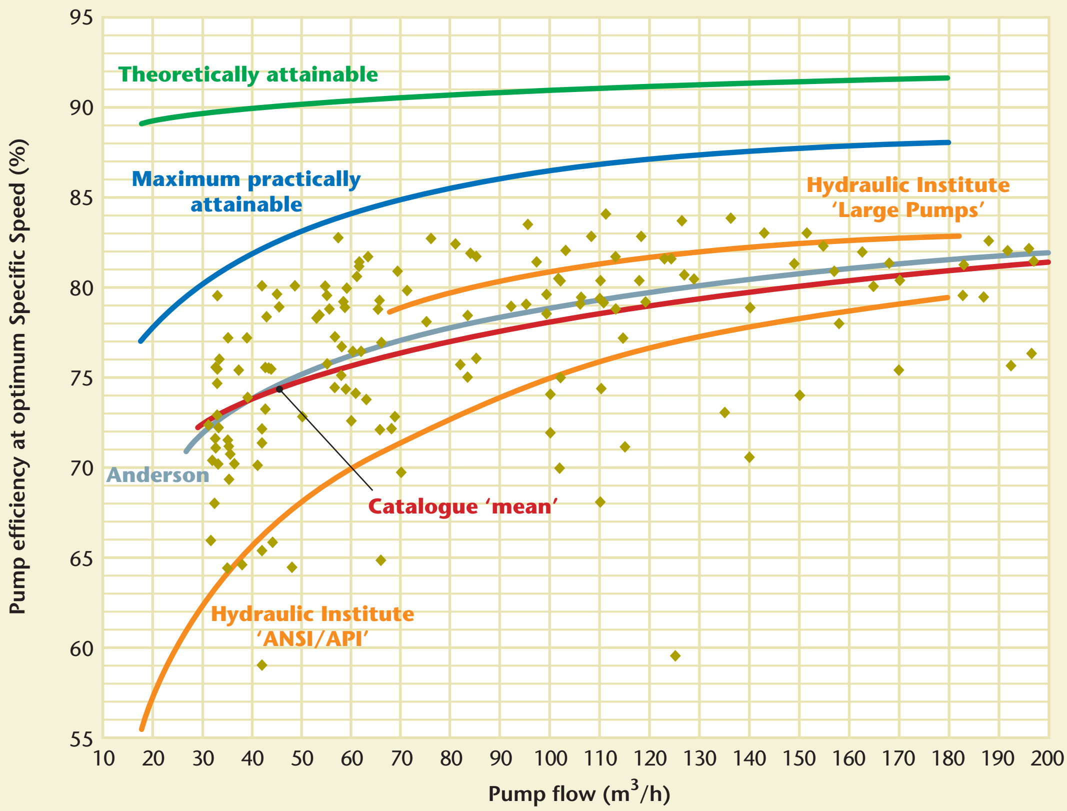


Figure 9: *Comparison of efficiencies of end suction pumps from various sources.*

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