

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 1 OF 32

BASIC DESIGN MANUAL SPD0027ERN PUMP REV. : 2 DATE : 2010. 11. 20



SAMSUNG ENGINEERING CO., LTD.

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 2 OF 32
DATE : 2010.11.20		

CONTENTS

	PAGE
1. SCOPE -----	4
2. FORMAT -----	4
3. PUMP SELECTION AND ESTIMATION OF POWER CONSUMPTION -----	4
3.1 General -----	4
3.2 Fluid Characteristics -----	4
3.3 Selection -----	5
3.4 Procedure -----	5
3.5 Program Available -----	8
3.6 Impeller Specific Speed -----	8
3.6.1 Impeller Specific Speed and Impeller Profile -----	8
3.6.2 Impeller Specific Speed and Pump Efficiency -----	9
3.6.3 Impeller Specific Speed and Shut-off Head -----	9
3.7 Affinity Laws -----	9
3.8 Pump Efficiency -----	10
3.9 Driver Power -----	10
3.10 Centrifugal pump Performance Correction for Viscous Liquid -----	11
4. OTHERS -----	11
4.1 Cooling Water -----	11
4.1.1 Cooling of Pedestals -----	11
4.1.2 Cooling of Stuffing Box Jackets -----	11
4.1.3 Cooling of Bearing Housing -----	11
4.1.4 Mechanical Seal Flushing -----	11
4.1.5 Cooling Water Rate -----	13
4.2 Temperature Rise and Minimum Flow Rate -----	13
5. REFERENCES -----	15
6. Revision history -----	32

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 3 OF 32
DATE : 2010.11.20		

CONTENTS

PAGE

APPENDIX

Appendix A. Example of Method for Converting Pump Performance Values with Clean Water for those with Viscous Liquid -----	16
Appendix B. Example Calculation of Acceleration Head -----	17

TABLES AND FIGURES

Table A-1. Calculation Result of Corrected Values -----	18
Fig. 3-1. Pump Selection Chart -----	19
Fig. 3-2. Procedure of Pump Selection and Estimation of Power Consumption -----	20
Fig. 3-3. Pump's Centerline -----	21
Fig. 3-4. NPSHR of Sundyne Pump -----	22
Fig. 3-5. NPSHR - Pump Type - Capacity -----	23
Fig. 3-6. NPSHR of Large Capacity Pump -----	24
Fig. 3-7. Characteristic of Pump NPSHR -----	25
Fig. 3-8. Impeller Designs and Corresponding Specific Speed Range -----	26
Fig. 3-9. Characteristic of Pump Head and Efficiency -----	27
Fig. 3-10. Efficiency of Sundyne Pump -----	28
Fig. 3-11. Efficiency of Centrifugal Pump -----	29
Fig. A-1. Performance Correction Diagram -----	30
Fig. A-2. Pump Performance Curve -----	31

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
DATE : 2010.11.20		PAGE 4 OF 32

1. SCOPE

This manual is a guide to the selection of pumps and the estimation of power consumption. Approximate water consumptions in pumps are given herein for estimation of utility requirements.

2. FORMAT

Calculations shall be conducted by using the HYDROMASTER program and required data shall be shown in the following forms:

Reciprocating Pumps	Form No.
Centrifugal Pumps	Form No.
Rotary pumps	Form No.

3. PUMP SELECTION AND ESTIMATION OF POWER CONSUMPTION

3.1 General

The normal variables in pump selection are location, function and type of hydraulic service. The most common objectives are low operating and maintenance costs, although it is not unusual to have these goals superseded by low initial cost. National purchase agreements, spare parts interchangeability and working relationships with local service personnel are other factors that influence selections.

3.2 Fluid Characteristics

A detailed listing of fluid characteristics is usually the first step in selection. The most important characteristics are:

- (1) The chemical identity of the fluid pumped, including such items as pH, dissolved oxygen concentration and historic data acquired during previous handling.
- (2) Absolute viscosity at pumping temperature and 60°F, usually given in centipoises. A substantial viscosity increase at ambient temperature could indicate that the liquid is unsuited for centrifugal pumps without steam jacketing.
- (3) Specific gravity of the fluid at the pumping temperature and 60°F. (or ambient).
- (4) Pumping temperature during normal operation and vapor pressure of the fluid measured at the pumping temperature.
- (5) A number of items that make up the Personality of the fluid. These include toxicity, explosive nature, crystallizing or polymerizing tendencies, and the presence of entrained

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 5 OF 32

gases. If there are over 3% solids by volume the fluid may qualify as a slurry and require special pump design such as rubber or hard-alloy linings.

3.3 Selection

Pump types must be selected by reviewing the heads, flow rate, fluid characteristics, costs and all other conditions involved. In some cases, final selection may have to be left to the judgement of the vendor and/or pump speciality engineers in charge.

Herein, the pump basic type is selected by using Fig.3-1 Pump Selection Chart based on the head and capacity.

If the items fall in the region of the centrifugal type in Fig.3-1, the centrifugal type should be adopted preferentially.

However, in the following cases, some other type must be considered:

- (1) Where the flowrate is smaller than 5 m³/hr (20 GPM).
- (2) Where the viscosity of the liquid to be handled is higher than 150 cst since the performance will lower if the viscosity is high.
- (3) Where proportioning is required.

Anyway, pump type selection should be made by discussion with the pump specialty engineers in charge.

3.4 Procedure

Provision of pumps is indicated on the process flow diagram. The basic procedure is as shown in Fig. 3-2.

By carrying out each step shown on the flow in Fig. 3-2, entries can be made in the project specifications and process information and the power consumptions can be calculated.

The procedure generally used is as follows:

(1) Flow rate

The normal flow rate is determined in the process design.

The design flow rate is determined on the basis of the normal flow rate herein.

Non-steady state flow rates, such as the maximum and minimum flow rates must be determined in each individual case with reference to the procedure discussed below.

The design flow rate should be the normal flow rate plus some allowance.

The criteria for the allowances are as follows:

- Feed : 0%
- Overhead Reflux : 20-30%
- Bottom : 15-20%

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 6 OF 32

In the case of refluxes and bottoms, if fluctuations in the operating conditions are expected to have large effects on the flow rates, such large allowances as 50% and 100% may have to be considered since the refluxes and bottoms are small in the material balance.

In any case, it is necessary that the process characteristics should be understood fully.

(2) Head

- First of all, the basic concepts of pump characteristic curve and hydraulics must be understood.
Actual calculations can be conducted by using the HYDROMASTER program.
- Suction head (in m or ft)
Suction heads shall be the static head from the bottom tangent line to the pump centerline in the case of vertical vessels from the bottom to the pump centerline in the case of horizontal vessels.
Pump centerlines can be read from Fig. 3-3 and the pump foundation height (EL +150 mm) shall be added thereto.
- Suction pressure at equipment and discharge pressure at destination
Normal operating pressure should be used.
- Line friction loss and the differential pressure of control valve.
Refer to section 12-1 "Line Sizing".
- The pressure drop in the pump suction strainer shall be regarded as 0.035 kg/cm² (0.5 psi) in usual cases.
- Pump Differential Head
Head can be calculated by the following equations:

$$H = (P_D - P_s) \frac{10}{\text{Sp.Gr.}} \quad (\text{for metric system})$$

$$H = (P_D - P_s) \frac{2.31}{\text{Sp.Gr.}} \quad (\text{for British system})$$

Where,

H : Head(m)(ft)

P_s : Pump suction pressure(kg/cm²)(psi)

P_D : Pump discharge pressure(kg/cm²)(psi)

Sp.Gr.: Specific gravity at pumping temperature

- NPSH available
NPSH available can be calculated by the following equations:

	BASIC DESIGN MANUAL	SPD0027ERN
		REV. : 2
DATE : 2010.11.20		PUMP

$$NPSH_A = \frac{10}{\text{Sp.Gr.}} \{(P_1 - P_2) - \Delta P\} + H \quad (\text{for metrical system})$$

$$NPSH_A = \frac{2.31}{\text{Sp.Gr.}} \{(P_1 - P_2) - \Delta P\} + H \quad (\text{for British system})$$

where,

P1: Operating Pressure at the suction liquid level (kg/cm²A) (psi)

P2: Vapor pressure at the suction temperature (kg/cm²A) (psi)
(Operating pressure of suction liquid)

H: Height between the vessel bottom TL and pump center line (m) (ft)

ΔP: Pressure drop in the pump suction line (kg/cm²) (psi)

(3) Number of rotations per minute

The number of rotations per minutes (RPM) should be decided based the recommendation made by the pump vendor.

RPM is a problem only in connection with NPSH required, erosion, corrosion and shaft seals. Since NPSH required can be calculated as a value, it will be necessary that the limit of RPM in each service should be kept in mind.

The procedure for calculating RPM from NPSH required is discussed in (4).

(4) NPSH required

When NPSH required must be calculated with high accuracy, the calculation must be done by the vendor, since NPSH required in one of the sales points, it varies from vendor to vendor. Inversely speaking, estimated NPSH required should be checked when the vendor's value has been received.

Generally, RPM and NPSH required should be calculated by the following simplified method:

(a) First, formulate NPSH required as follows:

$$NPSH_R (\text{allowable}) = NPSH_A - \alpha$$

$$\alpha = 0.2 \text{ m (0.7 ft)} \quad \text{Service below the boiling point}$$

$$\alpha = 0.3 \text{ m (1 ft)} \quad \text{Service in which boiling point liquid is to be handled}$$

(b) Plot NPSH required (allowable) and the flow rate on Figs. 3-4, 3-5, 3-6 and 3-7.

(c) Select RPM and suction types below the plotted line. In this case, RPM must be classified depending on the frequency of the power to be used as follows:

$$RPM = \frac{\text{Frequency, Hz}}{\text{Number of Poles (p)}/2} \times 60 = \frac{120\text{Hz}}{P}$$

(5) Other hydraulic factors

The acceleration head is the force required to accelerate the fluid in the suction line. This term is used with reciprocating pumps and is the head normally required in addition to the NPSH at the suction flange. The acceleration head is equal to:

	BASIC DESIGN MANUAL	SPD0027ERN
		REV. : 2
DATE : 2010.11.20		PUMP

$$H_a = LV_n C/gK$$

Where,

H_a : Acceleration head (ft)

L : Length of pipe (ft)

V_n : Fluid velocity in the suction pipe (ft/sec), at n rev./min. of the pump crankshaft

g : Gravity acceleration (ft/sec²)

C : 0.20 Simplex double acting pump

0.115 duplex double-acting pump

0.066 triplex double-acting pump

K : Varies from 2.5 for hot oil to 1.4 for deaerated hot water

K	Service
2.5	Hot oil
2.0	Most hydrocarbons
1.5	Amine, glycol, water
1.4	Deaerated water
1.0	Urea and liquids with small amounts of entrained gases
Refer to Appendix A and reference (3).	

3.5 Program Available

- Later -

3.6 Impeller Specific Speed

Impeller specific speed (N_s) is of significance as a value common to similar pumps.

The impeller specific speed can be used for the following purposes:

Estimate the impeller profile.

Estimate the pump efficiency.

Review RPM for a change.

Review the impeller dimensions for changes.

These are to be done only when required.

3.6.1 Impeller Specific Speed and Impeller Profile

$$(1) \quad N_s = \frac{NQ}{H^{3/4}}$$

Where, N : RPM (number of revolutions per minute)

Q : Flow rate

H : Head

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 9 OF 32

Generally, Ns is defined based on GPM for flow rate and feet for head. However, in the limited case, the definition base on other units may be used. So caution should be taken into account on this subject.

Conversion factors among Ns values are as follows:

Q	m ³ /min	ft ³ /min.	GPM
H	m	ft	ft
	1	2.438	6.68
	0.41	1	2.74
	0.1495	0.365	1

(2) Relationships between Ns and impeller profiles are as shown in Fig. 3-8.

3.6.2 Impeller Specific Speed and Pump Efficiency

The efficiency curve becomes sharp with an increase in Ns as seen from Fig. 3-9.

3.6.3 Impeller Specific Speed and Shut-off Head

The shut-off head increases in proportion to an increase in Ns. See Fig. 3-9.

3.7 Affinity Laws

The affinity laws are to be used to estimate the relationships between the performance and a change in RPM or in the impeller diameter.

(1) Change in RPM

If the speed is changed, with the impeller design (diameter and efficiency) fixed, the following conditions and characteristics will vary:

$$Q_2 = Q_1 \left(\frac{N_2}{N_1} \right)$$

$$H_2 = H_1 \left(\frac{N_2}{N_1} \right)^2$$

$$(BHP)_2 = (BHP)_1 \left(\frac{N_2}{N_1} \right)^3$$

(2) Change in impeller diameter

When the impeller diameter is to be changed, with the speed and efficiency fixed (without changing any other points in the design), the calculations can be conducted by the following equations:

$$Q_2 = Q_1 \left(\frac{D_2}{D_1} \right)$$

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
DATE : 2010.11.20		PAGE 10 OF 32

$$H_2 = H_1 \left(\frac{D_2}{D_1} \right)^2$$

$$(BHP)_2 = (BHP)_1 \left(\frac{D_2}{D_1} \right)^3$$

Where,

Q : Flow rate

N : Number of revolutions per minute (RPM)

H : Head

BHP : Brake horsepower

D : Impeller diameter

Note:

- The digit "1" added to letters means "before change"
- The digit "2" added to letters means "after change"
- The same units shall be used for the conditions before and after change.

3.8 Pump Efficiency

Pump efficiencies are to be determined by the vendor. Approximate calculations can be conducted by the following methods;

- (1) Efficiencies of Sundyne pumps can be calculated from the head and flow rate by using Fig. 3-10.
- (2) Efficiencies of centrifugal pumps can be calculated from the impeller specific speed (Ns) and flowrate (m³/min.) by using Fig. 3-11.

3.9 Driver Power

Driver powers can be calculated by the following equations:

$$KW = 0.163 (\text{Sp.Gr.}) Q H/e \quad (1)$$

$$= 2.72 (* 10^{-2}) Q P/e \quad (2)$$

$$BHP = Q H (\text{Sp.Gr.})/3960 e \quad (3)$$

Be careful of the units to be used for each individual equation.

Where,

KW : Brake horsepower

BHP : Brake horsepower Hp (= KW/0.7457)

Sp.Gr.: Specific gravity at pumping temperature

Q : Flow rate, m³/min. in Eq.(1), m³/hr in Eq.(2) and GPM in Eq.(3)

H : Head, m in Eq.(1) and ft in Eq.(3)

P : Differential pressure, kg/cm² in Eq.(2)

e : Pump efficiency

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
DATE : 2010.11.20		PAGE 11 OF 32

3.10 Centrifugal pump Performance Correction for Viscous Liquid

This correction should be considered for liquid exceeding 10 cst.

The method indicated in JIS B-8306 should be used.

Refer to Appendix B.

4. OTHERS

4.1 Cooling Water

4.1.1 Cooling of Pedestals

In the case of center support pumps, if the operating temperature is over 260°C (500°F), the pedestals shall be cooled with water as a rule.

4.1.2 Cooling of Stuffing Box Jackets

Pumps which are to be operated at the following conditions, shall be provided with cooling jackets over the stuffing box.

(1) Fluid Temperature: Over 150°C(300°F)

(2) Vapor pressure : Over 0.7 kg/cm²A (10 psia)

(API std 610 29.6)

4.1.3 Cooling of Bearing Housing

In cases where the fluid temperature is over 150°C (300°F), the bearings require cooling to prevent overheating owing to heat transmission through the shafts.

4.1.4 Mechanical Seal Flushing

The methods of seal flushing shall be decided by discussion with the vendor, but they shall be discussed generally from the standpoints shown next page.

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 12 OF 32

Conditions		Self-flushing	ExternalFlushing
Heat removal from mechanical seal sliding surfaces	Where the fluid,* temperature is low	0	
	Where the fluid * temperature is high	With flushing Oil cooler	0
Impurity removal from stuffing box	Where the fluid ** viscosity is low	0	-
	Where the fluid ** viscosity is high	With inter- cooler	
Where the fluid contains slurry		-	0

Note :

* : The temperature limit shall be 150 °C (300 ° F)

** : The viscosity limit shall be 150 cst at 150 °C (300 ° F)

See API 610 Fig. C-2, 3 and 4

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 13 OF 32

DATE : 2010.11.20

4.1.5 Cooling Water Rate

The cooling water rate for each of the following shall be as shown below and the cooling water rate for the pump shall be the total of all the individual cooling water rates.

Cooling Water rate

Cooling Water rate		
GPM	l/min.	Components Requiring Water Cooling
2	8	Bearing housing water jacket or cooling coil
2	8	Stuffing box water jacket
2	8	Water cooled pedestal
1/4	1	Staffing box gland quenching
1	4	Lantern ring with in-and out-connection
1/4	1	Lantern ring with inlet connection only
1	4	Flush tap for slurry service
10*	40*	Mechanical seal flushing cooler

Note :

* : Since the cooling water rates of individual mechanical seal flushing coolers vary largely from cooler to cooler, the above values have been used form approximate estimation. The cooling water system shall be of a closed type.

4.2 Temperature Rise and Minimum Flow Rate

If a pump is operated nearly at the shut-off point for a long time, the fluid temperature will rise, causing undesirable problems.

These problems can be avoided by the following means:

- (1) The pump should not be used under such conditions.
- (2) A part of the fluid should be passed through the bypass or recycled through the cooling system at some flow rate.

Calculations required for these are as discussed below.

- (1) Temperature rise during operation.

$$t = \frac{(1-e) \cdot H}{427 \cdot C_p \cdot e} \quad (\text{for metric system})$$

$$t = \frac{(1-e) \cdot H}{778 \cdot C_p \cdot e} \quad (\text{for British system})$$

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 14 OF 32

Where, t = temperature rise (°C) (°F)
 e = pump efficiency (fraction)
 H = head (m) (ft)
 C_p = Specific heat

(2) Temperature rise at shut-off

This can be formulated so shown below if the heat loss through the pump casing is disregarded.

$$t \text{ } ^\circ\text{C}/\text{min.} = \frac{\text{BHP at shut-off} \times 10.7}{(\text{liquid weight in pump, kg}) \cdot (C_p)}$$

$$t \text{ } ^\circ\text{F}/\text{min.} = \frac{\text{BHP at shut-off} \times 42.4}{(\text{liquid weight in pump, lb}) \cdot (C_p)}$$

(3) Minimum continuous flow-rate

The minimum flow rate at which the liquid does not vaporize in the pump, shall be calculated. Acceptability of this means has not yet been proved completely, but the means is widely used for usual operation.

The procedure is as described below.

- (a) Determine NPSH available.
- (b) Add NPSH available to the vapor pressure of the liquid at the suction conditions. Read the boiling point "t" of the liquid at the pressure from the vapor pressure curve.
- (c) Allowable temperature rise:
 $\Delta t \text{ allowable} = t - \text{actual pumping temperature.}$
 Use an average temperature rise of 8°C (15°F) for boiler feed water.
- (d) Calculate the minimum safe continuous flow efficiency roughly.

$$e_{\min.} = \frac{H \text{ shut-off}}{427 \cdot (\Delta T \text{ allowance}) \cdot C_p + H \text{ shut-off}} \quad (\text{for metric system})$$

$$= \frac{H \text{ shut-off}}{778 \cdot (\Delta T \text{ allowance}) \cdot C_p + H \text{ shut-off}} \quad (\text{for British system})$$

(e) Minimum safe flow

Read the flow rate at $e_{\min.}$ from the pump performance curve. It is the minimum safe flow.

Where,

t : temperature defined in (b), (°C) (°F)
 $\Delta t \text{ allowable}$: Allowable temperature rise defined in (c), (°C) (°F)
 $e_{\min.}$: Pump efficiency defined in (d) (fraction)
 $H \text{ shut-off}$: Head at shut-off (m) (ft) (Read this from the performance curve)
 C_p : Specific heat of liquid handled

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
DATE : 2010.11.20		PAGE 15 OF 32

5. REFERENCES

- (1) William H. Stindt, Chemical Engineering/Deskbook, October 11, 1971.
- (2) Applied Process Design for Chemical and Petrochemical Plants
- (3) Cameron Hydraulic data 16th Edition, 1-18

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 16 OF 32

Appendix A : Example of Method for Converting Pump Performance Values with Clean Water to those with Viscous Liquid

When a viscous liquid is handled, the performance of a pump is affected by the viscosity, resulting in a decrease in total pump head and discharge, and also in an increase in shaft power. It is not practicable, however, to clearly define a principle for estimating the pump performance obtainable with the use of a different liquid viscosity from the pump performance obtained with a certain liquid viscosity.

Fig. A-1 cited from the US Hydraulic Institute Standards for Centrifugal Pumps (1969, 12th edition) shows a method for estimating, for centrifugal pumps, the pump performance obtainable with the use of a viscous liquid where the pump performance obtained with the use of clean water is known. This method may also be used for selecting a pump suitable for a specific liquid viscosity.

The values on the curves in Fig. A-1 are the mean values from the test results obtained with the use of an oil in an ordinary single-stage pump of 50 to 200 mm bore, and should be under the following limitations.

(1) The diagram should be used only within the scale range shown therein, and should not be extended beyond that range.

(2) The diagram should be applied exclusively to open-impeller or closed-impeller type volute pumps of ordinary design, and should not be used for mixed-flow or axial-flow type pumps or pumps of special design.

(3) The diagram should be applied only to Newtonian fluids.

Practical Example

To obtain the pump performance curve when an oil with a kinematic viscosity of 1,000 SSU (220 cSt) and a weight per unit volume of 0.90 kgf/l is handled from the pump performance curve (Fig. A-2) obtained with clean water.

First find the value of Q_N corresponding to the maximum efficiency point o be 2.84 m³/min. from the performance curve in Fig. A-2, then find the values of total pump head and pump efficiency corresponding to the respective values of discharge, $0.6 \times Q_N$

$0.8 \times Q_N$, and $1.2 \times Q_N$ from the diagram (See Q_w , H_w , and E_w in Table A-1, upper column). Secondly, using $Q_N = 2.84$ m³/min., pump total head of 30.5 m, and viscosity of 1,000 SSU, find the corresponding correction factors from Fig. A-1 (See C_Q , C_H , and C_E in Table A-1, middle column), then calculate the corrected values as shown in Table A-1, and further calculate the shaft power with the use of the oil according to the following equation.

Corrected shaft power KW

$$= \frac{0.163 \times (\text{corrected discharge, m}^3/\text{min.}) \times (\text{corrected total pump head, m}) \times (\text{weight per unit volume of oil, kgf/l})}{\text{correction pump efficiency}}$$

The performance curves with the use of the oil may be obtained by plotting these corrected values in Fig. A-2.

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 17 OF 32

Appendix B. Example Calculation of Acceleration Head

Given a 2" × 5" triplex pump running at 360 rpm and displacing 73 GPM of water with a suction pipe made up of 4 feet of 4 inch pipe and 20 feet of 6 inch pipe.

Average velocity in 4-inch pipe

$$V_4 = \frac{0.321 \times 73}{12.73} = 1.84 \text{ fps}$$

Average velocity in 6-inch pipe

$$V_6 = \frac{0.321 \times 73}{28.93} = 0.811 \text{ fps}$$

Acceleration head in 4-inch pipe

$$V_{a4} = \frac{4 \times 1.84 \times 360 \times 0.066}{1.4 \times 32.2} = 3.88 \text{ ft}$$

Acceleration head in 6 inch pipe

$$V_{a6} = \frac{20 \times 0.811 \times 360 \times 0.066}{1.4 \times 32.2} = 8.55 \text{ ft}$$

Total acceleration head

$$ha = 3.88 + 8.55 = 12.4 \text{ ft}$$

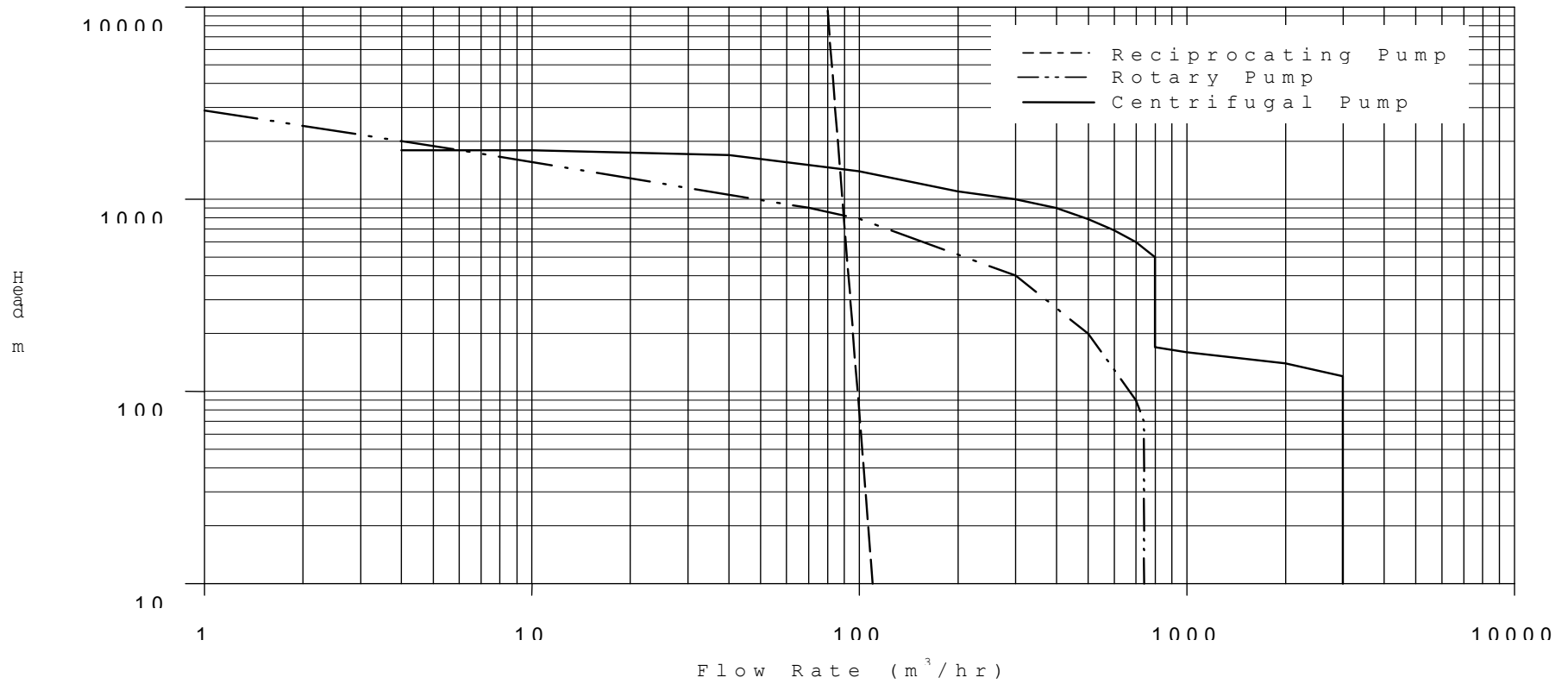
Note: ha is added to the NPSHR by the pump

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 18 OF 32

Table A-1. Calculation Result of Corrected Values

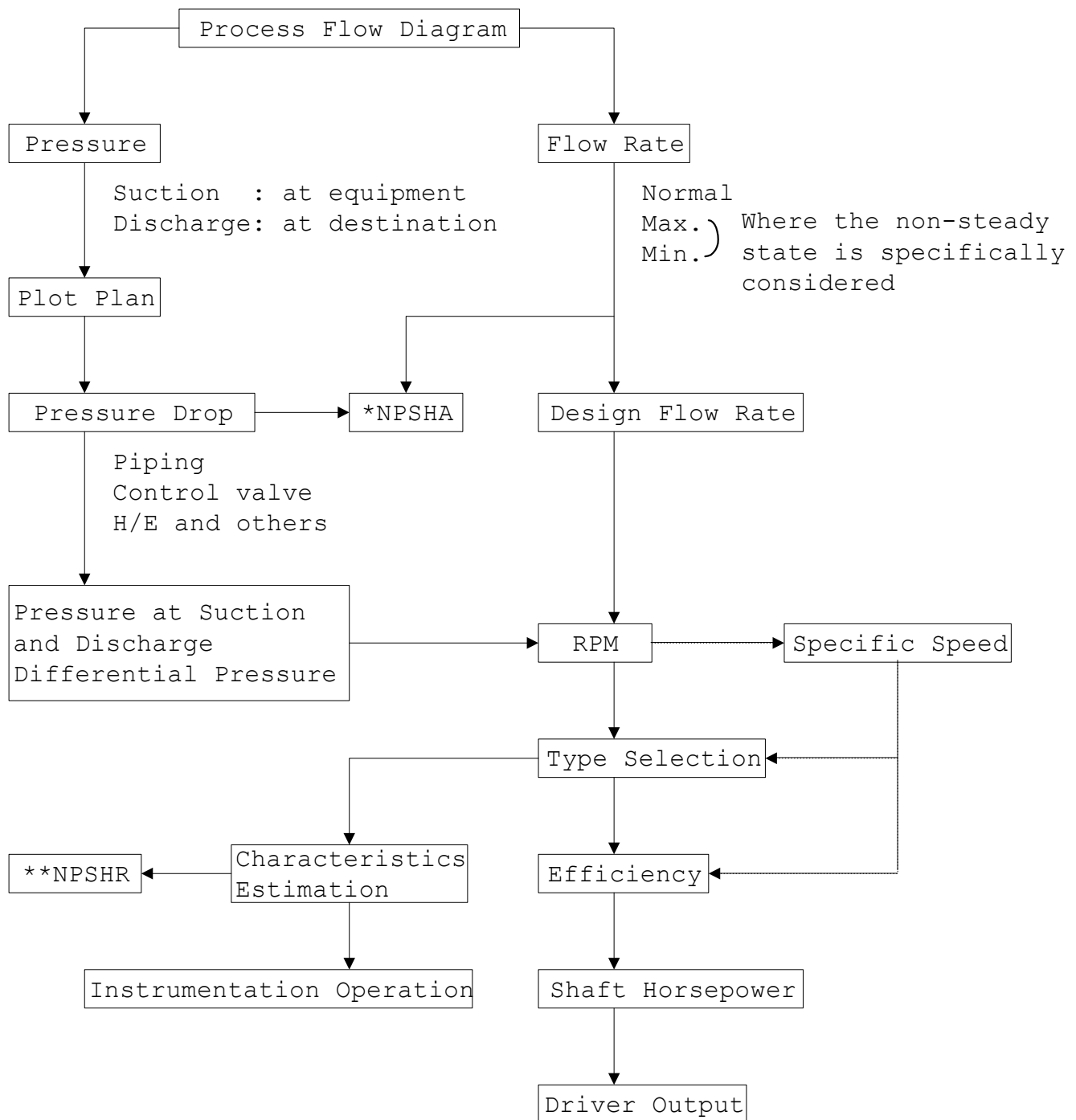
		0.6 × QN	0.8 × QN	QN	1.2 × QN
When using clean water:					
Discharge	QW m3/min	1.7	2.27	2.84	3.41
Tool pump head	HW m	34.3	33	30.5	26.2
Pump efficiency	EW %	72.5	80	82	79.5
Viscosity of oil :		1000 SSU			
From Reference	CQ	0.95	0.95	0.95	0.95
Diagram 1:	CH	0.96	0.94	0.92	0.89
(Correction Factor)	CE	0.63	0.63	0.63	0.63
When using oil (corrected value):					
Discharge	QW × CQ	1.62	2.16	2.7	3.24
Tool pump head	HW × CH	32.9	31	28.1	23.3
Pump efficiency	EW × CE	45.7	50.4	51.7	50.1
Weight per unit volume of oil, kgf/l		0.9			
Shaft Power with the use of oil, kw		17.1	19.5	21.5	22.1

Fig. 3-1 Pump Selection Chart



	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 20 OF 32

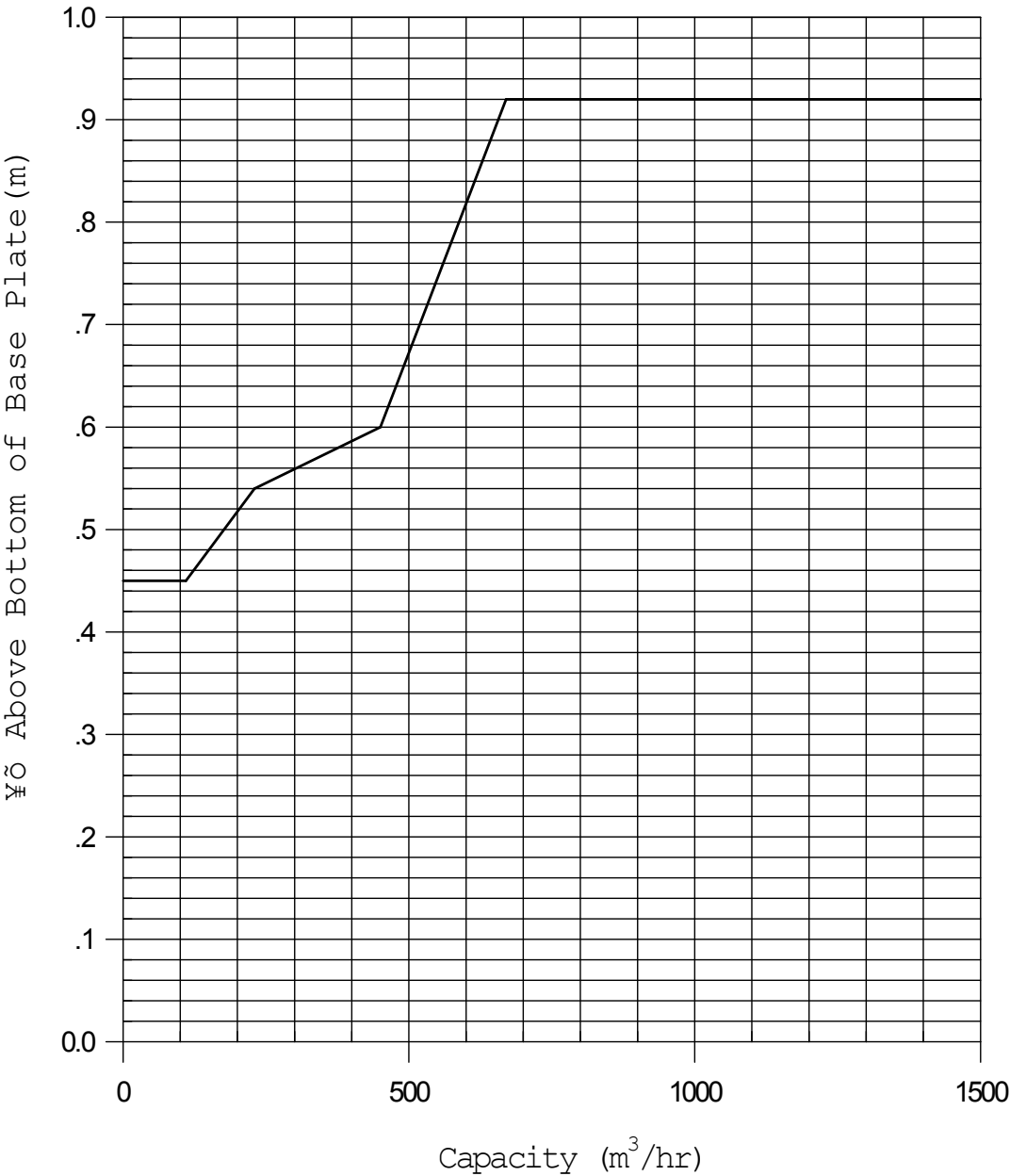
Fig. 3.2 Procedure of Pump Selection and Estimation of Power Consumption



* : NPSH available

** : NPSH required

Fig. 3-3 Pump's Centerlines



	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
DATE : 2010.11.20		PAGE 22 OF 32

Fig. 3-4. NPSHR of Sundyne Pump

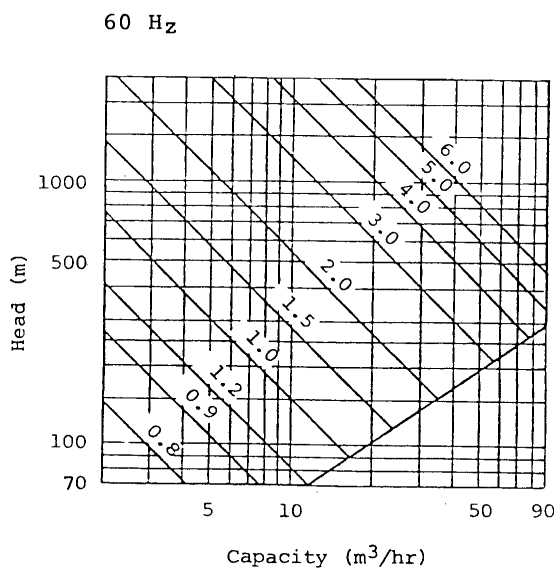
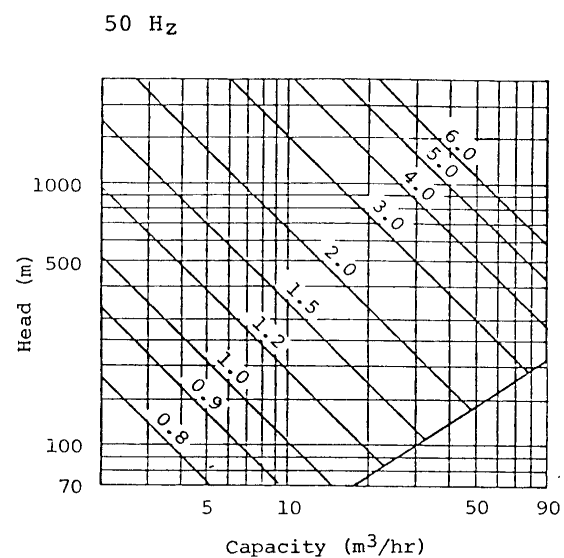
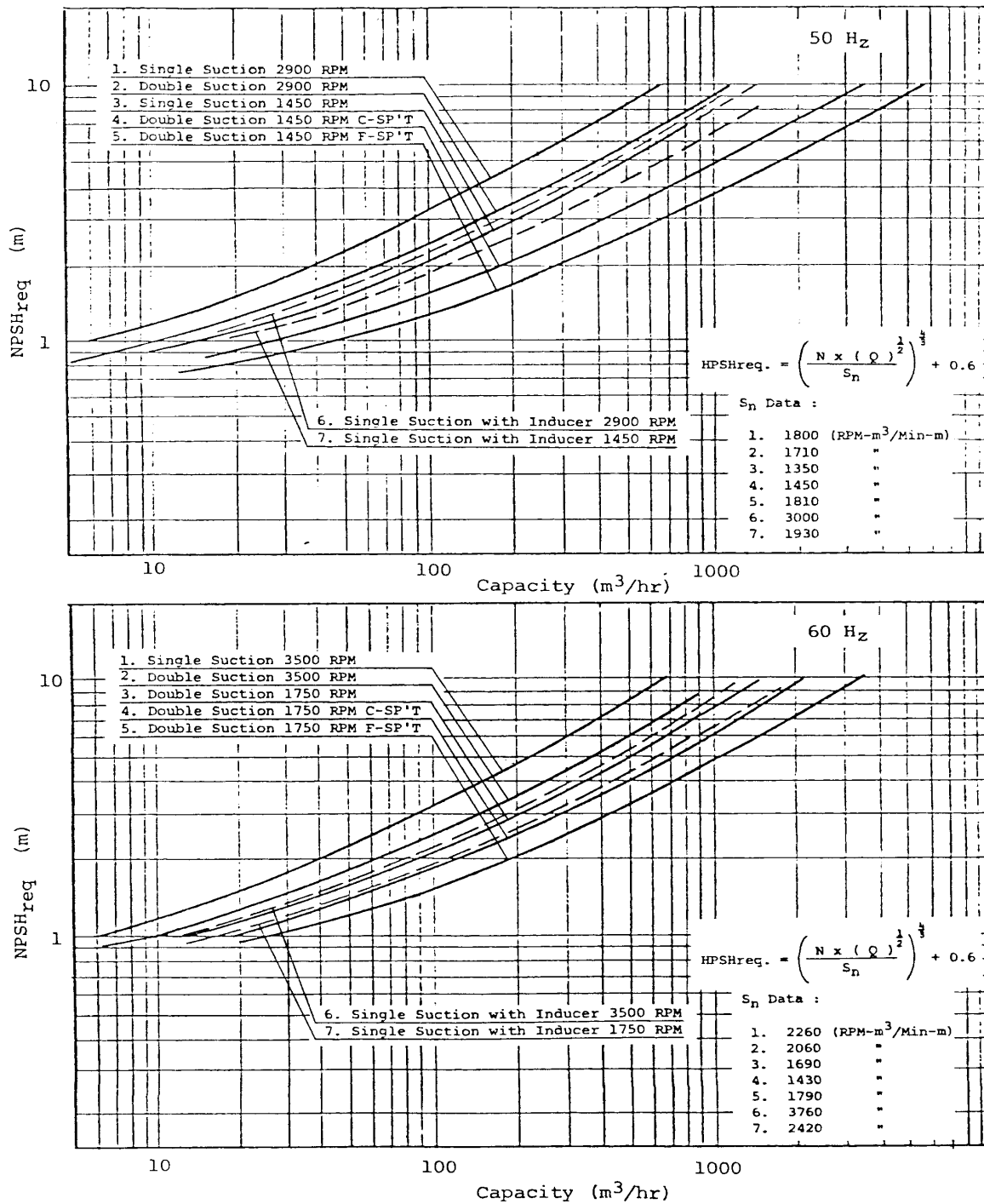


Fig. 3-5 NPSHR - Pump Type - Capacity

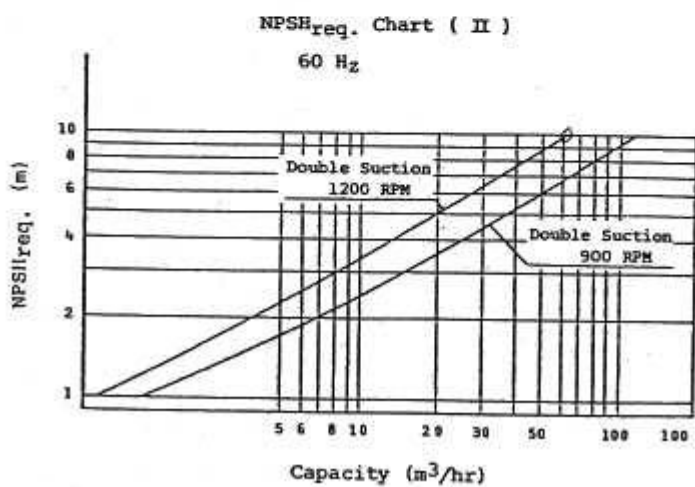
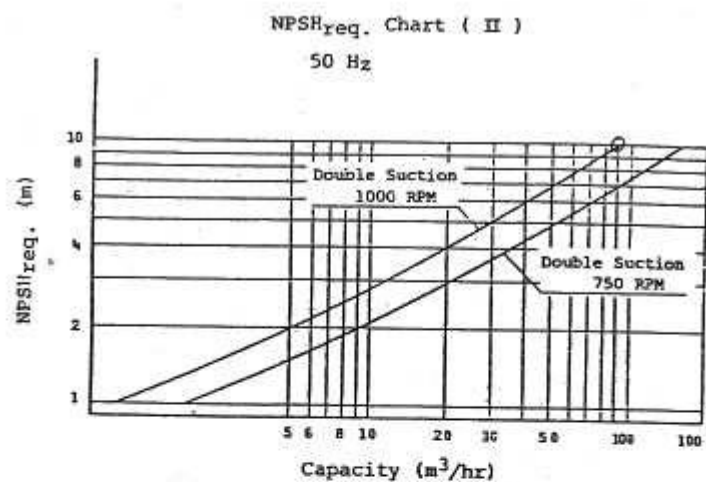


Note :

Sn : Suction Specific Speed

	BASIC DESIGN MANUAL PUMP	SPD0027ERN
DATE : 2010.11.20		REV. : 2
		PAGE 24 OF 32

Fig. 3-6. NPSHR of Large Capacity Pump



Note :
$$\text{NPSH}_{\text{req.}} = \left(\frac{N \times (Q)^{\frac{1}{2}}}{S_n} \right)^{\frac{4}{3}} + 0.6$$

$$S_n = 1600$$

Fig. 3-7 Characteristic of Pump NPSHr

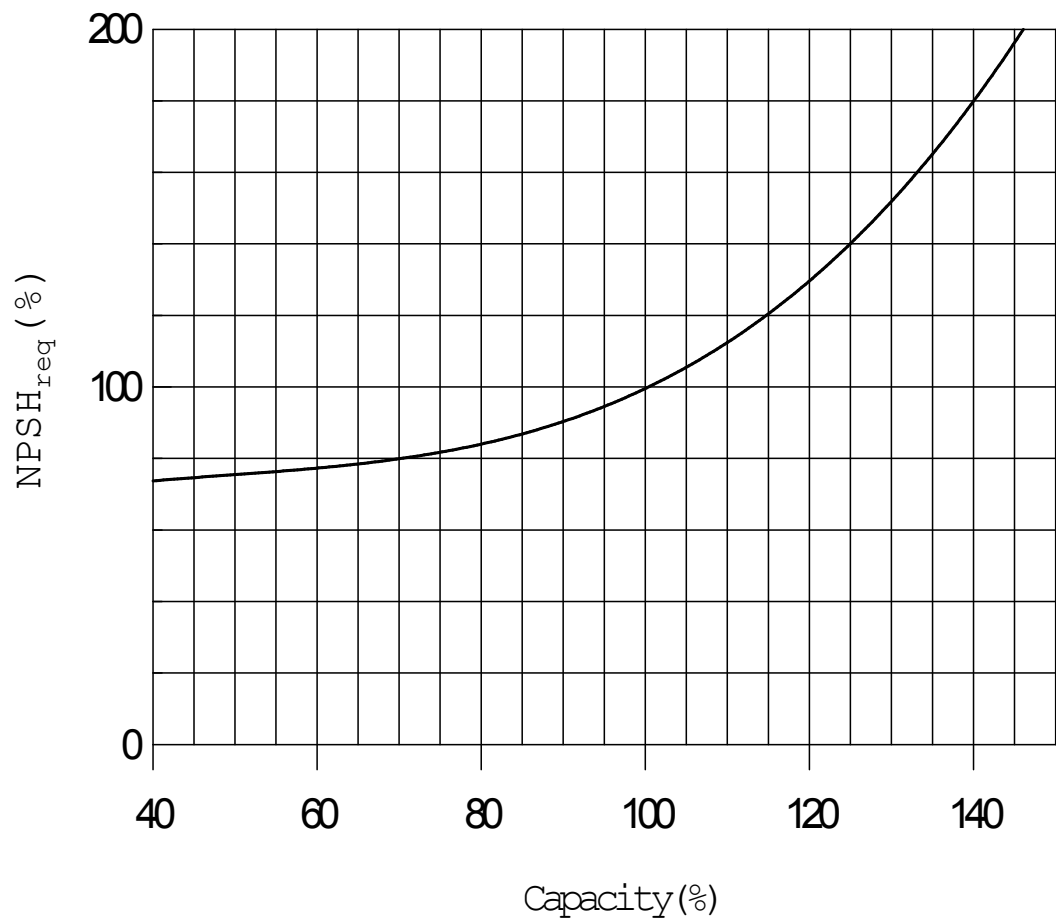


Fig. 3-8. Impeller Designs and Corresponding Specific speed range

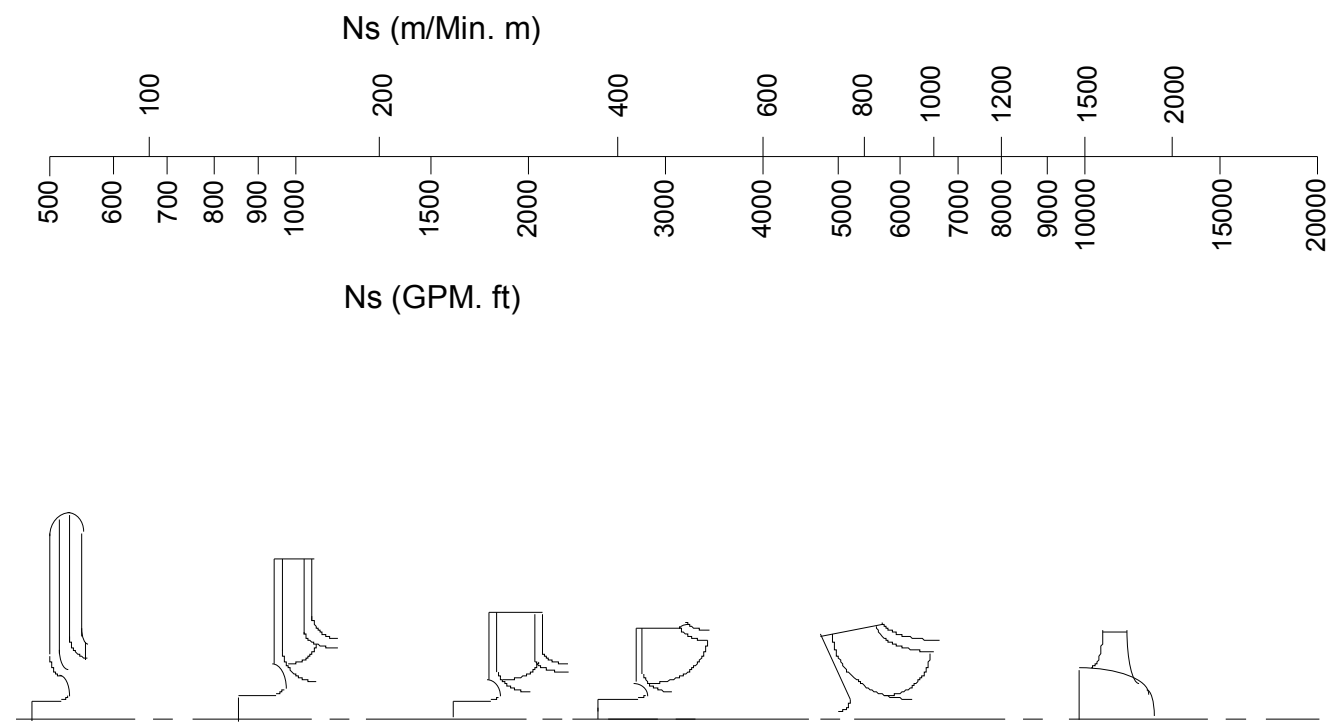


Fig. 3-9 Charateristic of Pump Head and Efficiency

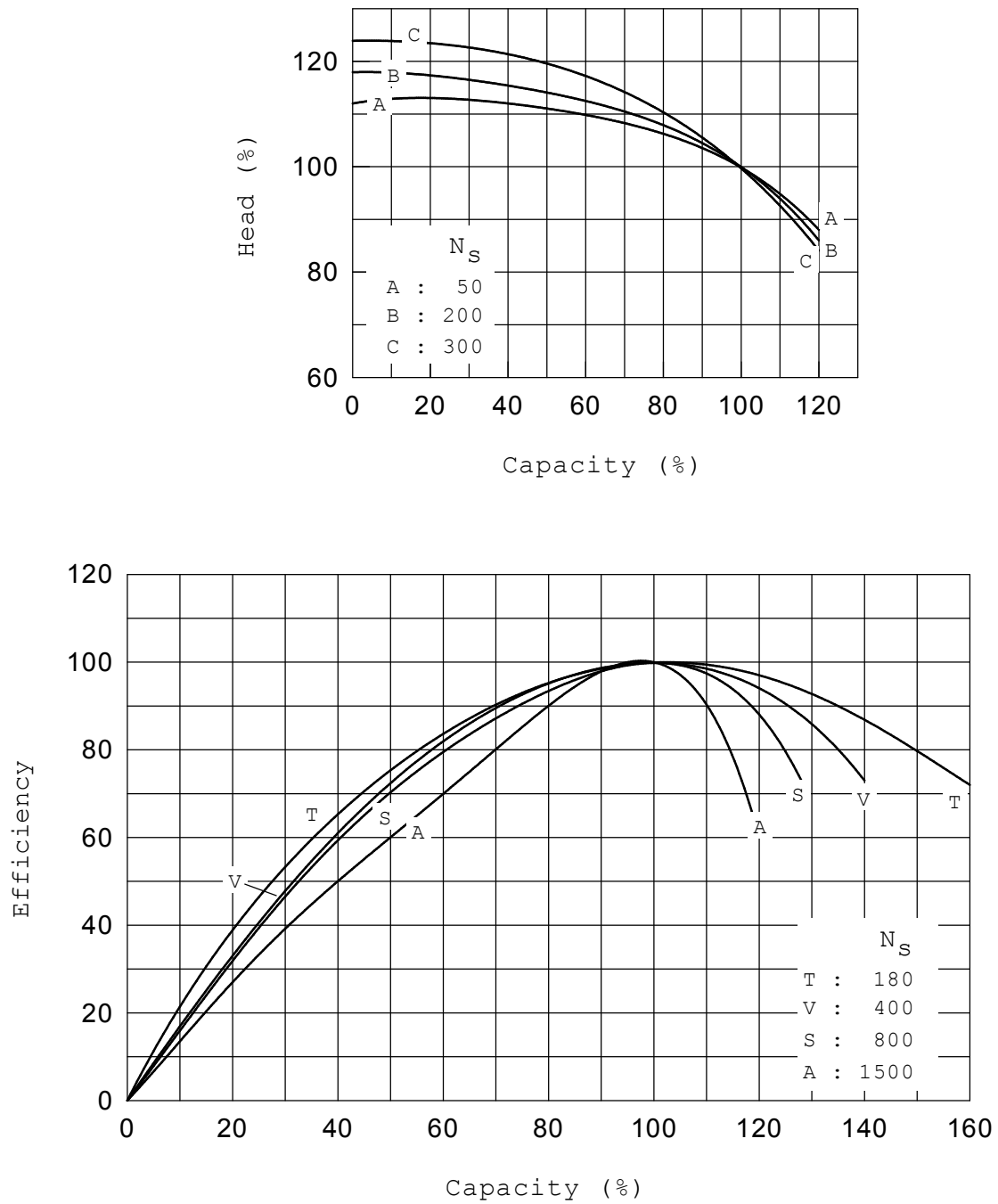


Fig. 3-10 Efficiency of Sundyne Pump

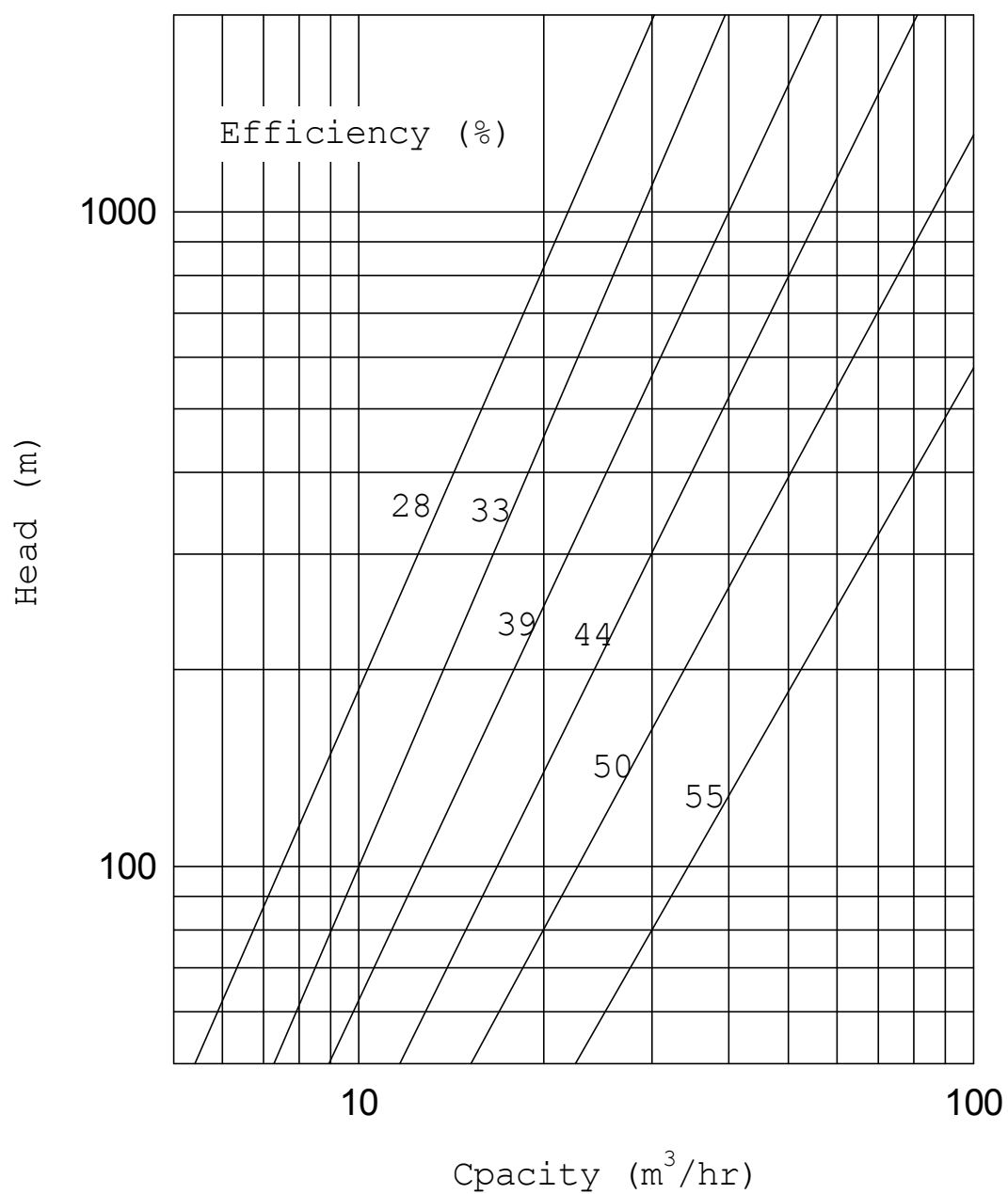
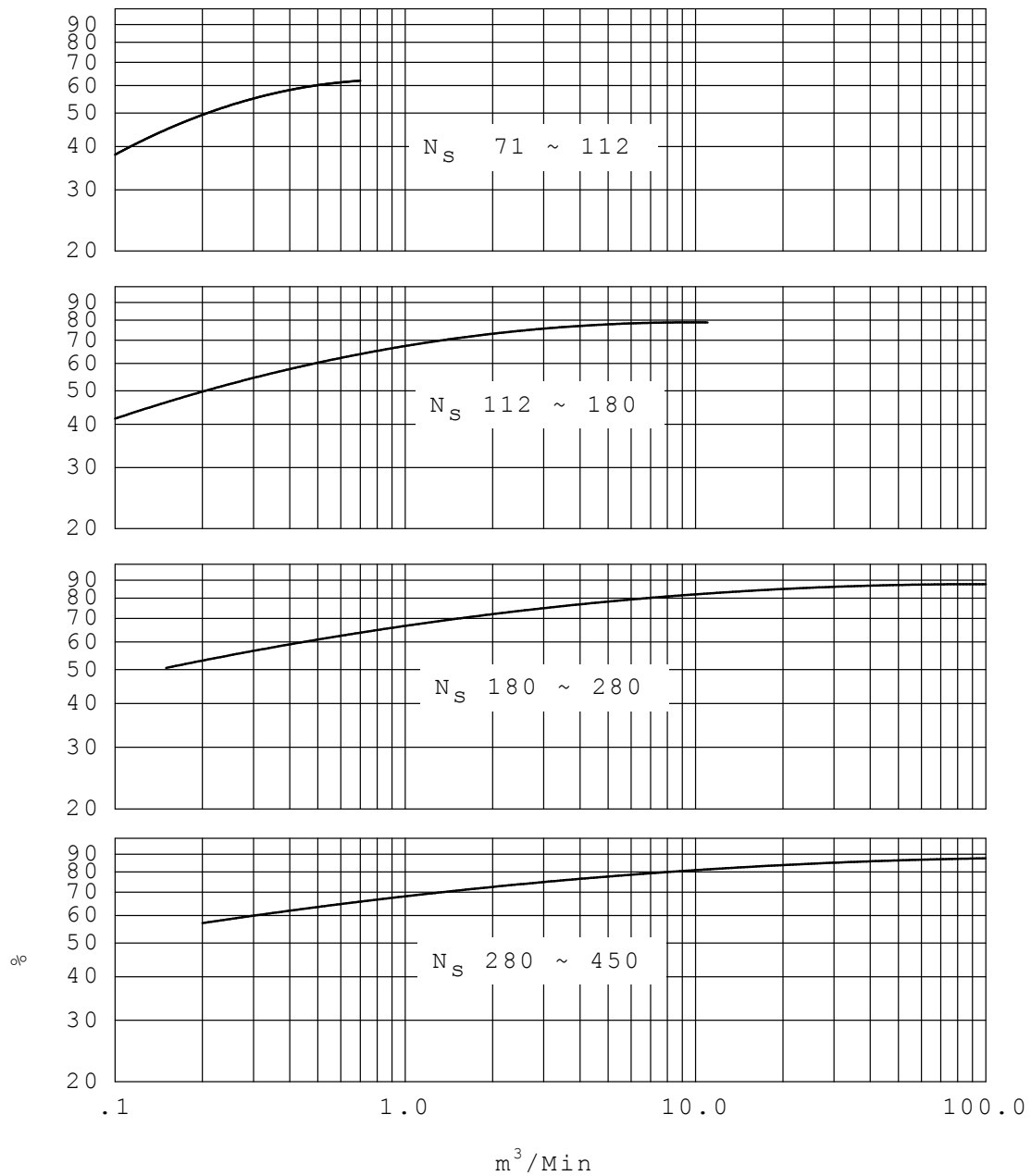


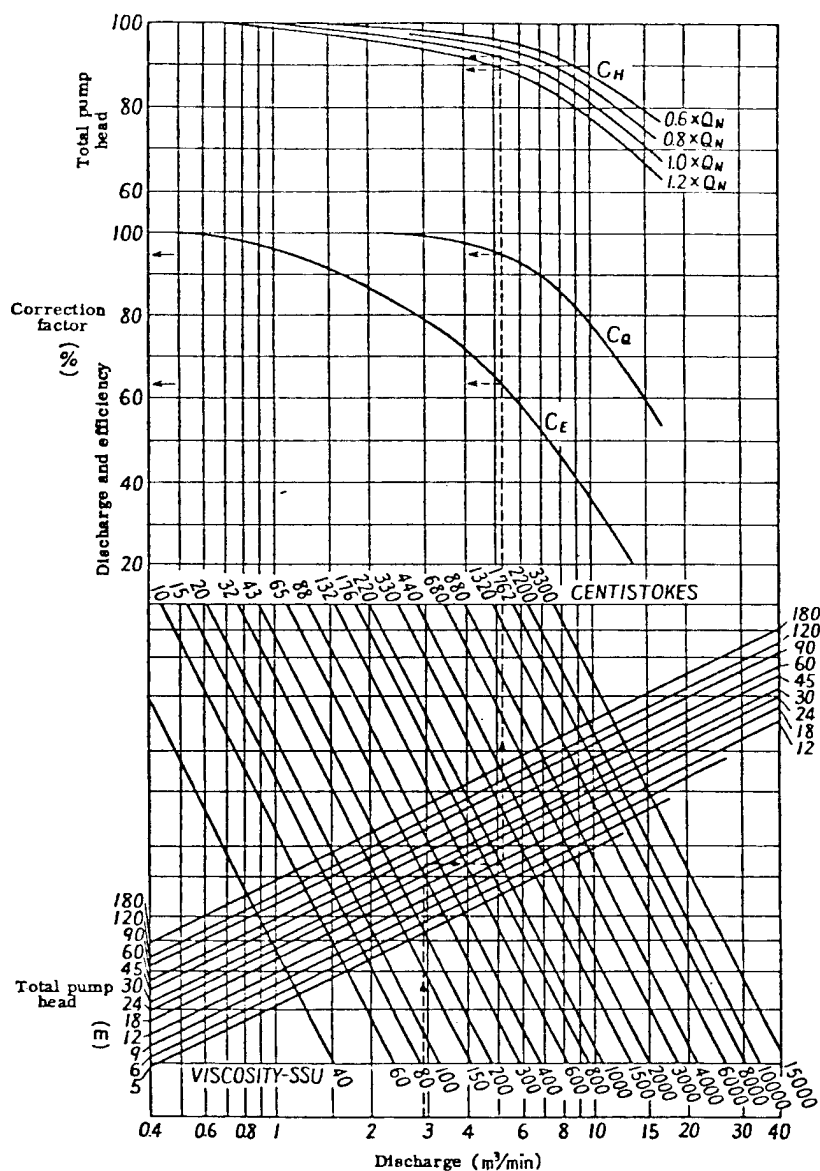
Fig. 3-11 Efficiency of Centrifugal Pump



Note : Fig. 3-11 are charts provided by the Japan Hydraulic Institute. HYDECS P.G. uses Fig. 3-11 with corrections.

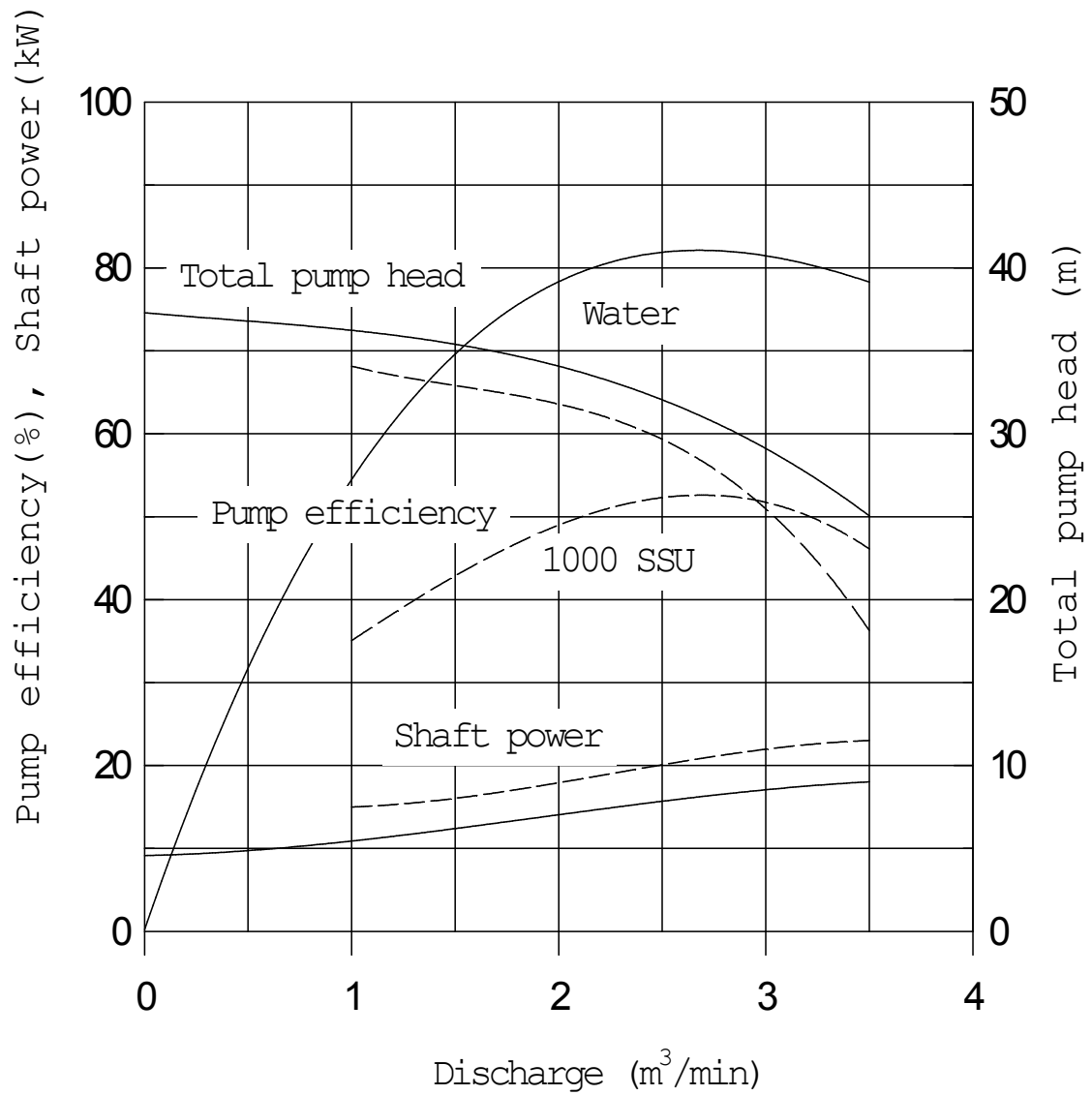
	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
DATE : 2010.11.20		PAGE 30 OF 32

Fig. A-1. Performance Correction Diagram



	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 31 OF 32

Fig. A-2 Pump Performance Curve



	BASIC DESIGN MANUAL PUMP	SPD0027ERN
		REV. : 2
		PAGE 32 OF 32

6. Revision History

Rev. No.	Date	Scope	Description
0	98. 4. 17	All pages	- First Edition - Team : Process Eng'g Team - Made by : J.H.Park J.E.Lim - Checked by : B.I.Lee S.B.Jo J.C.Ro - Approved by : S.G.Oh
1	03. 9. 30	4,6,7,8, 10,12,13, 14,16,18, 19,20,24	Partially Revision - Made by : P.S.Choi - Checked by : M.H.Oh J.C.Ro - Approved by : C.S.Jung
2	2010.11.20	All pages	Document number revision - Prepared by : J.I. Kim - Reviewed by : H. Sung, J.C. Ro, H.H. Kwak, M.H. Oh, S.U. Hong - Approved by : E.D. Lee