CASE STUDIES – CS 8

High vibration and cavitation noise in Pump No: CP 7B

High vibration and cavitation noise in Pump No: CP 4B/ CP 5B

Introduction:

The following report has been prepared based on the observations made and flow/pressure data collected during the visit of Himadri Sen & Niloy Deb to the job site. The analysis has been supported by the performance and design information that we have about the existing pumps:

Pump Details:

1. Pump Serial No: 81221366/920/1
   Manufacturer: Mather & Platt
   Pump Model: 200/250 AST MK1
   Design flow: 425 m^3/hr, 20m @1480 rpm
   Rated flow: 350 m^3/hr, 25m
   Actual Flow at present- Not measured. Pump runs with delivery valve throttled.

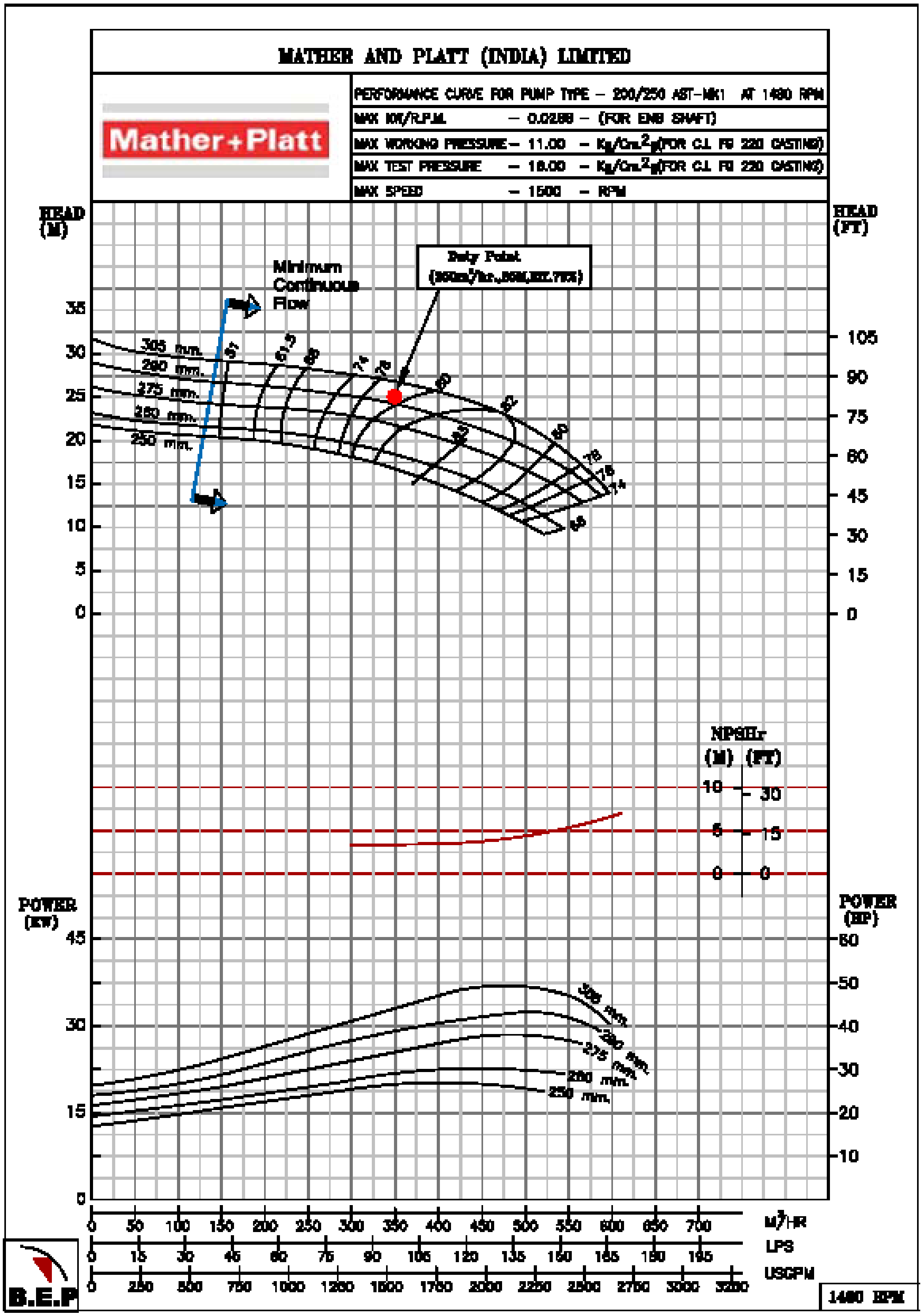
   - **Main Problem:** High Vibration

2. Pump Serial No: 81221366/900
   Manufacturer: Mather & Platt
   Pump Model: 350/450 CST
   Design flow: 1800 m^3/hr, 60m @1480 rpm
   Rated flow: 1500 m^3/hr, 60m
   Actual Flow at present- 1160 m^3/hr

   - **Main Problem :** High vibration and cavitation noise

Problems with Pump Model: 200/250 AST MK1

This is a relatively low head pump and it will be seen from the performance curve attached that at part flow operation, the H-Q curve becomes flat. This zone represents a region susceptible to recirculation. Suction pipe layout for this pump is not ideal since there is a sharp bend parallel to the pump shaft very close to the suction flange. The vibration levels are high at part flow operation due to recirculation, effect of bend and radial thrust load. However, when the valve is opened, the vibration level becomes normal and acceptable. The pump bearing temperature was normal and no cavitation noise was present during our observations. Since this is a low energy pump working under positive suction head, our observations indicates that no remedial action is necessary other than running the pump near its rated capacity. We understand that this can be ensured after the plant is commissioned. The rest of the report, therefore, does not deal with this pump.


MATHER AND PLATT (INDIA) LIMITED
Mather+Platt
PERFORMANCE CURVE FOR PUMP TYPE – 200/250 AST-MK1 AT 1480 RPM
MAX KW/R.P.M. – 0.0288 – (FOR EN8 SHAFT)
MAX WORKING PRESSURE – 11.00 – Kg/Cm²g(FOR C.I. FG 220 CASTING)
MAX TEST PRESSURE – 16.00 – Kg/Cm²g(FOR C.I. FG 220 CASTING)
MAX SPEED – 1500 – RPM
HEAD (M)
HEAD (FT)
Minimum Continuous Flow
Duty Point
305 mm.
290 mm.
275 mm.
260 mm.
250 mm.
NPSHr
(M) (FT)
POWER (KW)
POWER (HP)
M³/HR
LPS
USGPM
B.E.P
1480 RPM

Problems with Pump Model: 350/450 CST

The pump has high vibration and very prominent cavitation noise.

Suction Layout:

Observations:

1. Sharp bend at the pump suction parallel to the pump shaft.

Effects:

- Axial Thrust
- Unequal flow and flow disturbances
- Increased vibration

Explanation:

When a bend in the suction line is located asymmetrically relative to the suction of the pump distribution of the flow between the two halves of the impeller may be uneven. This occurs when a uniform flow passes through a single bend, because it exits with a non uniform velocity distribution as shown in the figure 1. As a result of this distortion of the uniformity of flow, each suction inlet of the impeller receives a different flow rate.

A double-suction pump can be considered to consist of a combination of two identical, single-suction impellers operating in parallel and discharging into a common casing. Let curve A in fig 2 represent the Q-H characteristics of each of the single suction impellers. Because of their parallel operation, the pump delivers a resultant flow rate equal to the sum of all the flow rates that each of these impellers delivers against the given head. The actual Q-H curve of the pump shows a flow rate equal to twice the flow rate delivered by each of the given head. This is shown as curve B. We have also shown a curve C which represents the resistance of the pumping system to a given flow rate. The actual flow against which the pump operates is at the intersection M of curve B & C. It is equal to the flow Qb= 2Qa.

This means that a bend immediately upstream of the suction inlet and parallel to the shaft of a double-suction pump causes an uneven distribution of the flows entering each side of the impeller. One side of the partial impeller delivers a flow rate equal to Qa-δQa against head H1. The other side of the impeller delivers a flow rate Qa+δQa against a head H2. At the impeller outlet both flows encounter the same resistance Hm which has been determined by the intersection of curves B & C.

At the impeller outlet, the flow rate Qa-δQa encounters a sudden drop in pressure from H1 to Hm. This effect is similar to that of a sudden breakdown in the discharge line. A sudden acceleration of the flow occurs, resulting in cavitation upstream of the corresponding partial impeller. The flow rate Qa+δQa, encounters a sudden increase in the resistance to flow, from H2 to Hm. This has an effect equivalent to a sudden shut off of a discharge valve, and strong water hammer may result and the pump may operate with high vibration.

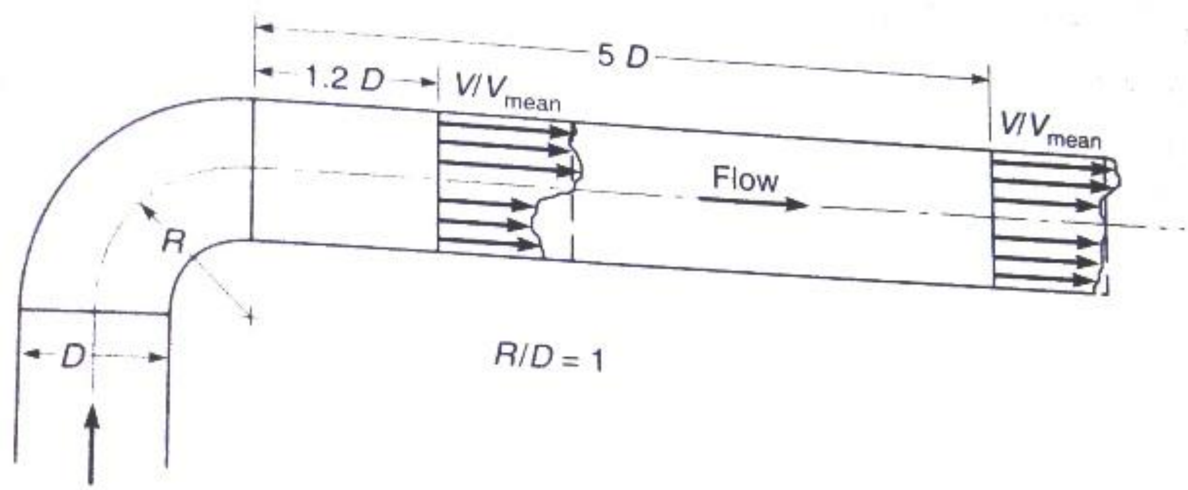


Figure 1

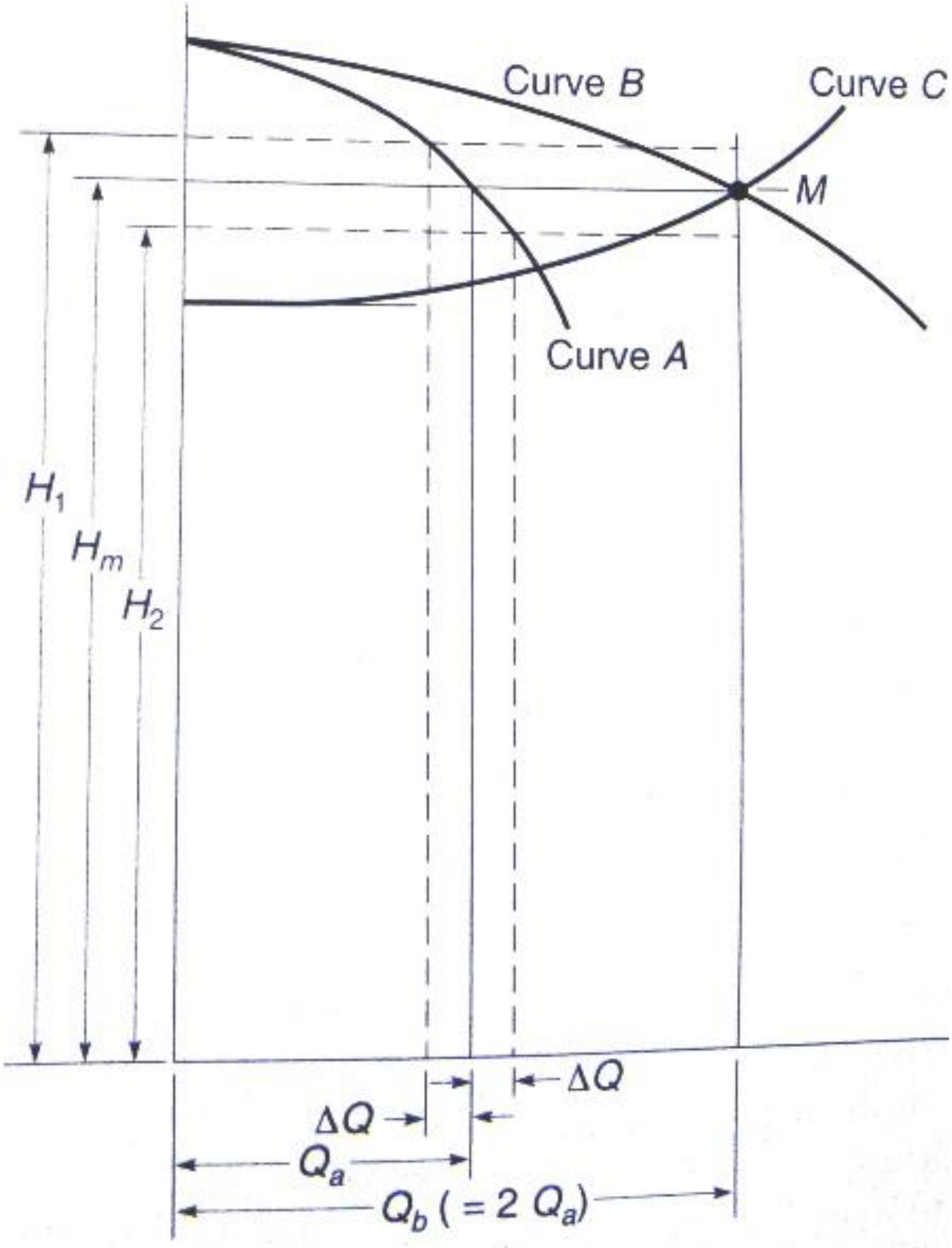

Curve B
Curve C
M
Curve A
H_1
H_m
H_2
ΔQ
ΔQ
Q_a
Q_b (= 2 Q_a)

Figure 2

Cavitation noise & high vibrations:

Observations:

- Part flow operation leading to recirculation

Effects:

- High radial load
- Recirculation

Explanations:

<u>Calculation of radial load:</u>

This pump has its best efficiency point (BEP) at 1800m3/hr, 60m.

Pump rated operating point = 1500 m3/hr, 60m

Actual operating point - 1160m3/hr, 79m

Specific speed = 2508 in US units

Impeller diameter = 475mm

Impeller width= 104 mm (including shrouds)

Radial thrust= K .H. B2. D2. P. g = 5.81KN (at actual operating point)

Radial thrust = 4 KN (at rated duty of 1500 m3/hr) and 2 KN (at BEP)

Above shows that the radial load is high at the current operating point.

Recirculation:

The pump is operating at part flow i.e. 1160m3/hr which is 64% of the BEP flow. According to ANSI HI 9.6.3-1997, if the specific speed is below 4500 US units the preferred operating region lies between 70% and 120% of the BEP. Otherwise flow reversal takes place leading to cavitaion and vibration.

Supporting calculations:

According to Warren H Fraser, the recirculation is the point of reversal and that point occurs when the centrifugal pressure field and dynamic pressure fields are equal.

Here,

Outside impeller diameter D2 = 475mm

Eye diameter D1= 280mm

Hub diameter h1=110mm

Discharge diagram vane angle β2= 22 deg

Inlet diagram vane angle β1= 30 deg

N= 1480 rpm

Here, D1/D2 =0.58

Flow1 = ($D2^2$x B2 x N/6.089)x Cm2/U2 m3/s…………………………………….1

Flow2= (D1 ($D1^2$-$h1^2$)xN x$\frac{Ve}{U1}$)/ (2.53 x10^{10}) m3/s…………………………………….2

Since D1/D2=0.58 so suction recirculation is either (1) or (2) whichever is greater.

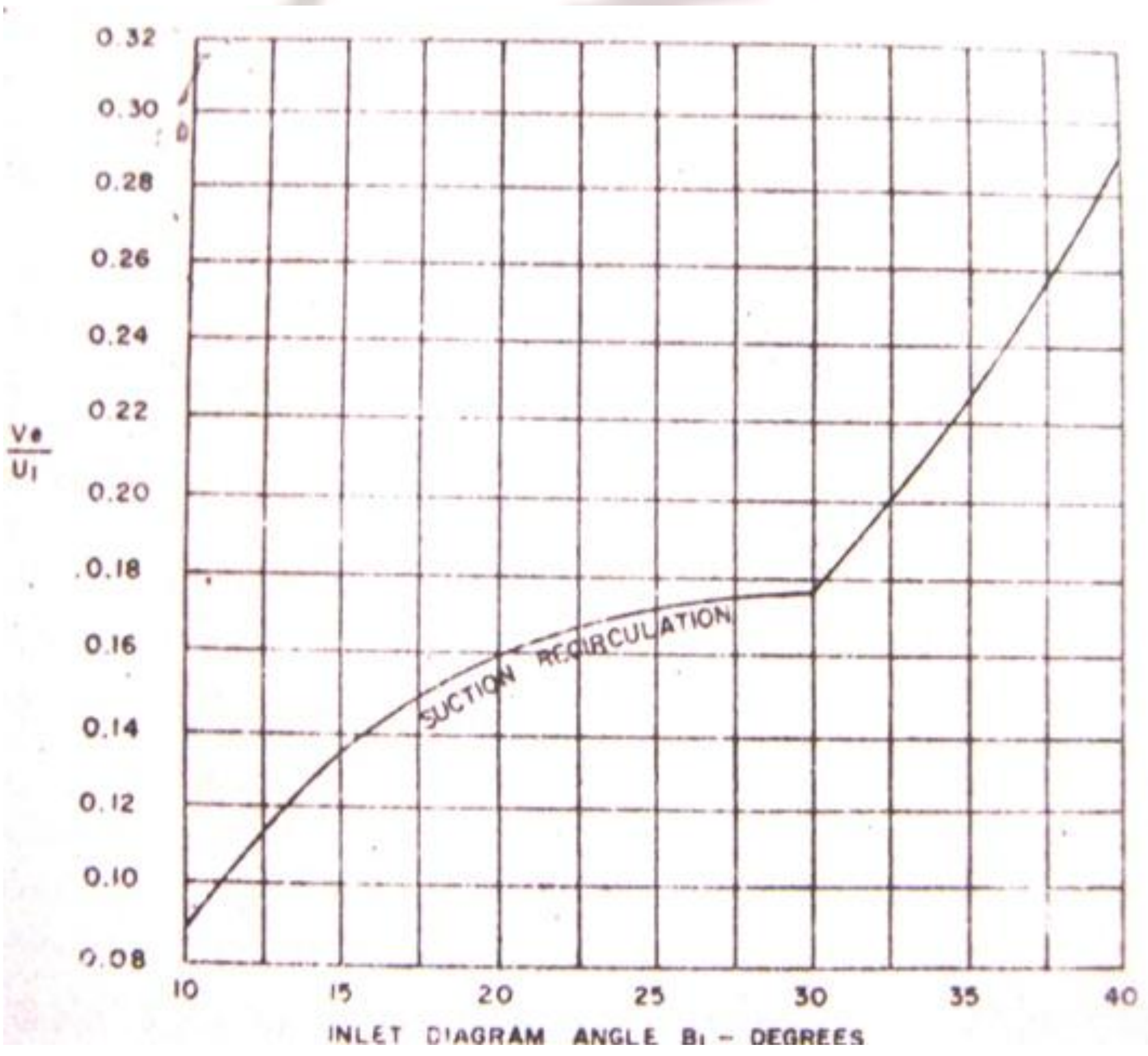
From curves,

Cm2/U2= .086

Ve/U1= 0.17

By calculating the values, Flow2 is greater than Flow1 and it is approximately 1500m3/hr.

This suggests that for any flow less than the rated flow of 1500 m3/hr, recirculation can not be avoided in this installation while using the existing impeller.


0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
Ve/U1
10
15
20
25
30
35
40
SUCTION RECIRCULATION
INLET DIAGRAM ANGLE B1 – DEGREES

<u>Recommendations:</u> **For 350/450 CST our recommendations will be as follows:**

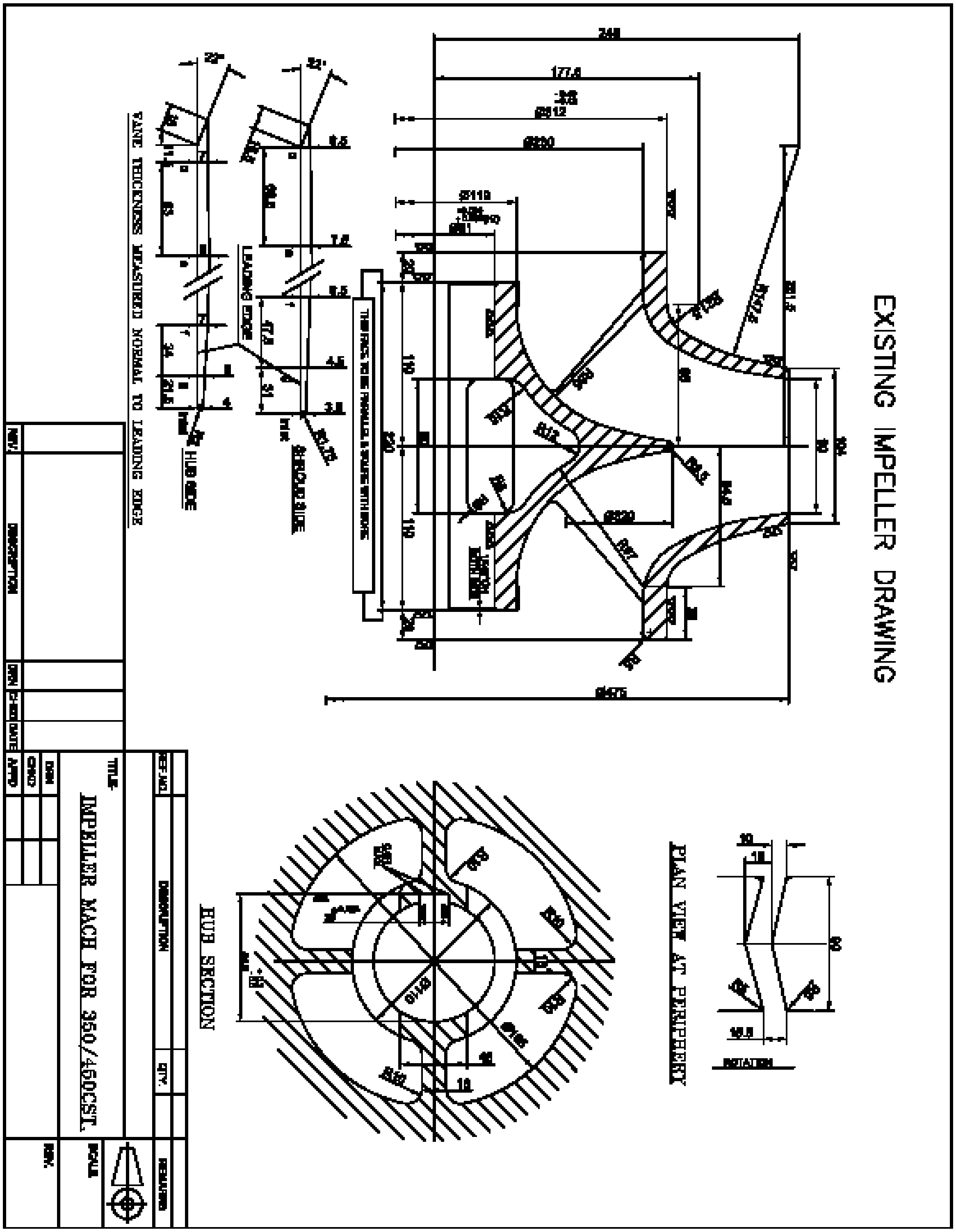
1. **Providing flow guides in the suction bend to ensure equal flow to both the impeller eyes.**

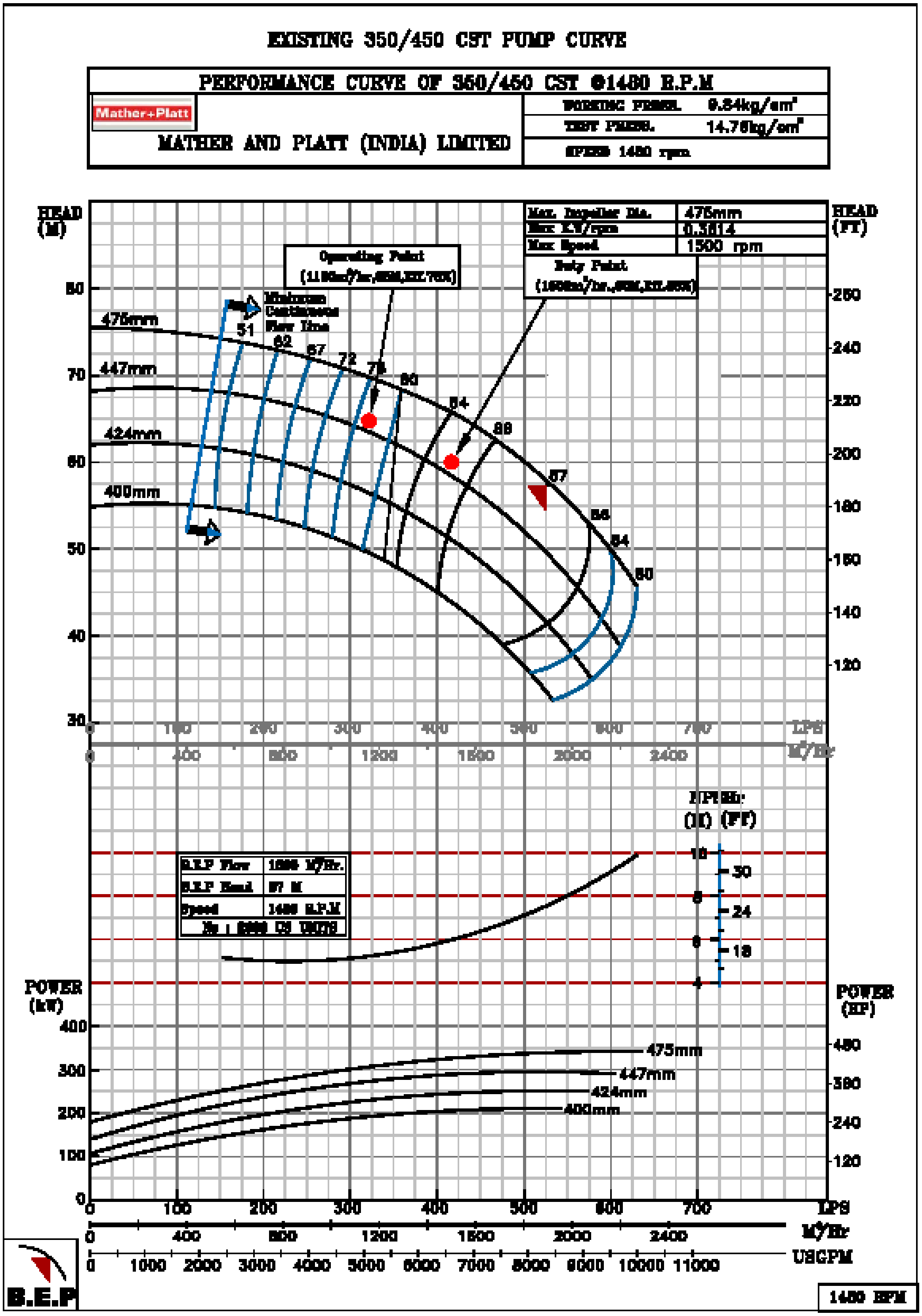
2. **Operating the pump closer to its rated duty/ best efficiency point to avoid recirculation flow and cavitation.**

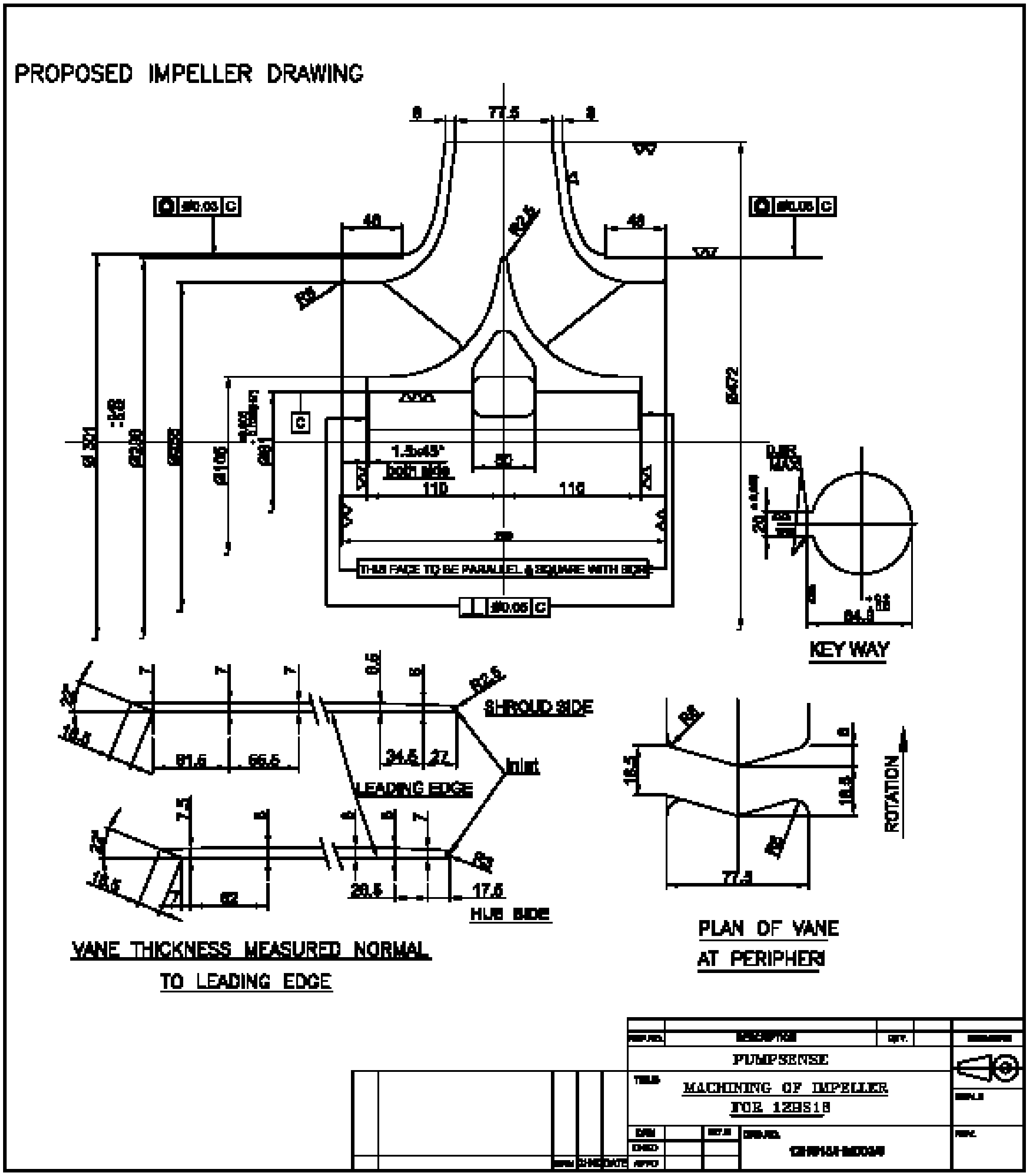
3. **If recommendation 2 cannot be implemented because of system constraints, it will be beneficial to use a low capacity impeller with BEP close to the current operating flow of 1160m^3/hr. We were informed that the capacity of the pumps will continue to be about 1160m^3/hr for a long time to come.**

Proposal for a New impeller for 350/450 CST:

You will find attached approximate dimensions of the impeller of 350/450 CST. We have also attached the dimensions of an impeller that we can specially design for the installation. You will find the respective characteristic curves for these two impellers attached to this report. We can supply one impeller and a pair of wear rings to you for trying out on one of the existing pumps. If this reduces vibration and cavitation noise significantly you may change all the impellers to low capacity ones. Existing impellers and wear rings can be retained and used when the capacity requirement moves back to at least 1500m^3/hr per pump.


EXISTING IMPELLER DRAWING
VANE THICKNESS MEASURED NORMAL TO LEADING EDGE
HUB SECTION
PLAN VIEW AT PERIPHERY
IMPELLER MACH FOR 350/450CST.


EXISTING 350/450 CST PUMP CURVE
PERFORMANCE CURVE OF 350/450 CST @1480 R.P.M
Mather+Platt
MATHER AND PLATT (INDIA) LIMITED
SPEED 1480 rpm
Max. Impeller Dia. 475mm
Max Speed 1500 rpm
Operating Point
Duty Point
Minimum Continuous Flow Line
HEAD (M)
HEAD (FT)
475mm
447mm
424mm
400mm
LPS
M³/Hr
NPSHr
(M) (FT)
POWER (kW)
POWER (HP)
USGPM
1480 RPM
B.E.P


PROPOSED IMPELLER DRAWING
77.5
1.5x45°
both side
110
110
THIS FACE TO BE PARALLEL & SQUARE WITH BORE
KEY WAY
SHROUD SIDE
Inlet
LEADING EDGE
HUB SIDE
ROTATION
VANE THICKNESS MEASURED NORMAL
TO LEADING EDGE
PLAN OF VANE
AT PERIPHERI
PUMPSENSE
MACHINING OF IMPELLER
FOR 12HS18

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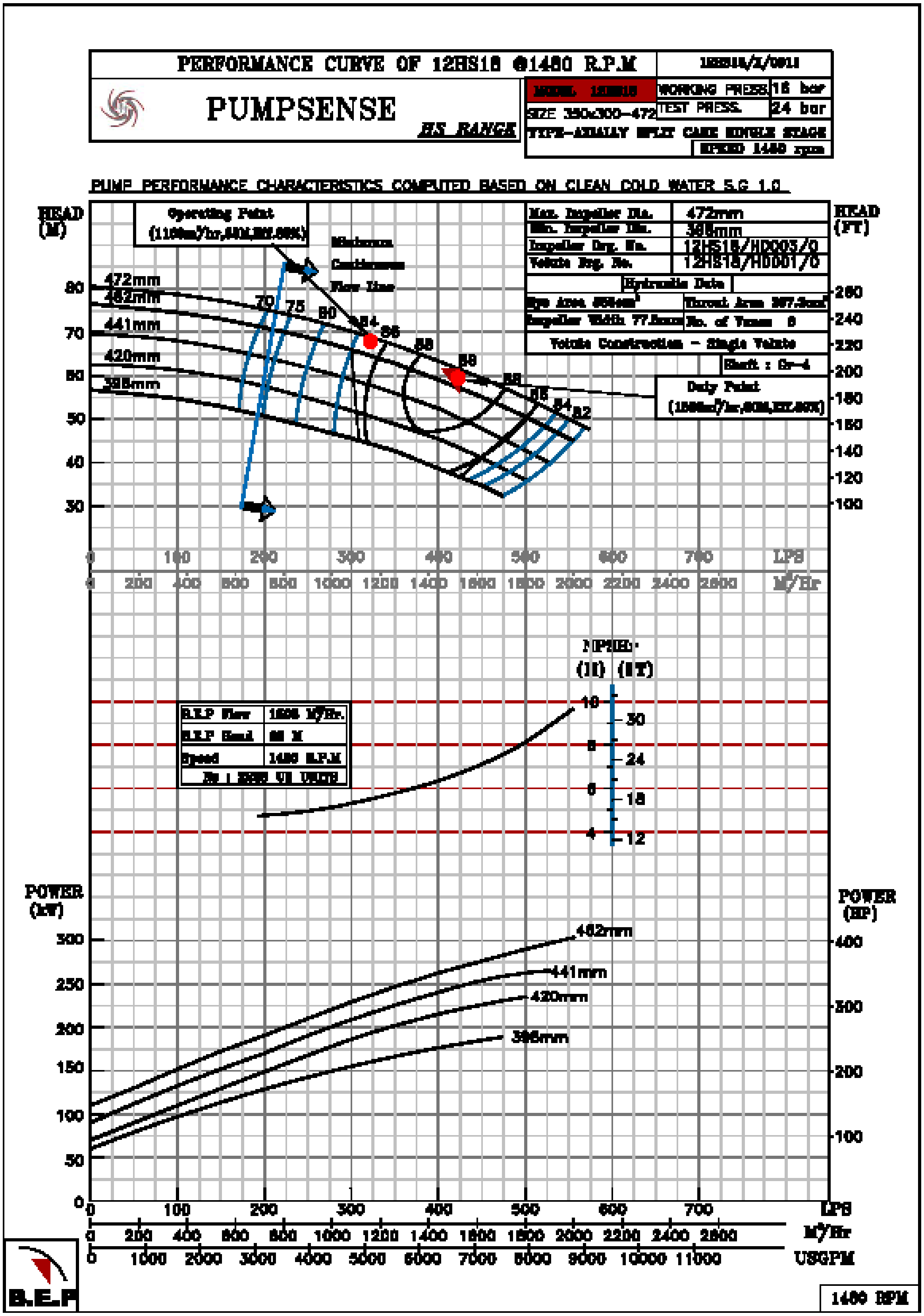
PERFORMANCE CURVE OF 12HS18 @1480 R.P.M
PUMPSENSE
HS RANGE
WORKING PRESS. 16 bar
TEST PRESS. 24 bar
SIZE 350x300-472
PUMP PERFORMANCE CHARACTERISTICS COMPUTED BASED ON CLEAN COLD WATER S.G 1.0
HEAD (M)
HEAD (FT)
Max. Impeller Dia. 472mm
Min. Impeller Dia. 398mm
Impeller Drg. No. 12HS18/HD003/0
Volute Drg. No. 12HS18/HD001/0
Hydraulic Data
Volute Construction - Single Volute
Operating Point
Minimum Continuous Flow Line
Duty Point
472mm
462mm
441mm
420mm
398mm
LPS
M³/Hr
NPSHr
(M) (FT)
B.E.P Flow
B.E.P Head
Speed 1480 R.P.M
POWER (kW)
POWER (HP)
USGPM
B.E.P
1480 RPM