CASE STUDY #3

26TH INTERNATIONAL PUMP USERS SYMPOSIUM

SIMPLE HYDRAULIC RETROFIT SOLVES FIELD VIBRATION PROBLEM OF A HORIZONTAL PUMP

By

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INTRODUCTION

- HORIZONTAL WATER TRANSFER PUMP
  - SINGLE STAGE, DOUBLE SUCTION, 500HP
  - PUMP SPEED : 1778 RPM
  - DESIGN FLOW RATE : 12,000 GPM
  - DESIGN HEAD : 150 FT
  - ~550 HP
- SERVICE
  - TURBINE COOLING WATER SUPPLY PUMP
  - 2 PUMPS IN POWER PLANT
  - FIELD SERVICE WAS CALLED DUE TO VIBRATION PROBLEMS DURING COMMISSIONING OF THE PUMP

INTRODUCTION

- HORIZONTAL TURBINE COOLING WATER PUMPS
  - SEVERE FIELD VIBRATION AT START UP
    - ALIGNMENT WAS CHECKED
    - ROTATING ASSEMBLY BALANCING WAS CONFIRMED
    - FIELD MECHANICAL ADJUSTMENTS WERE NOT SUCCESSFUL

INITIAL FIELD VIBRATION LEVELS

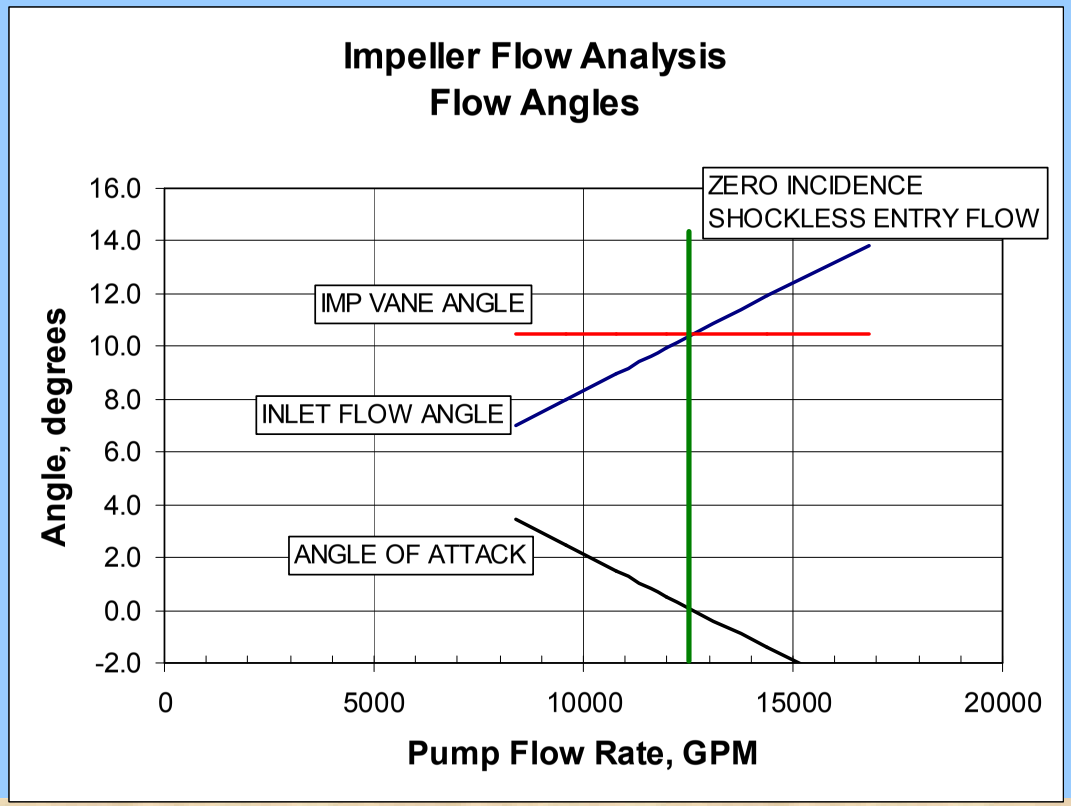
INITIAL VIBRATION MEASUREMENTS	
Pump A	
Location, Pump Bearing Housing	Overall Readings, in/sec
Out Board Horizontal	0.3366
Out Board Vertical	0.4739
In Board Horizontal	0.2577
In Board Vertical	0.4169
Axial	0.1187
Pump B	
Location, Pump Bearing Housing	Overall Readings, in/sec
Out Board Horizontal	0.3801
Out Board Vertical	0.3903
In Board Horizontal	0.2480
In Board Vertical	0.3380
Axial	0.1250

HYDRAULIC ASSESSMENT
DESIGN PERFORMANCE

- Field performance measurements
  - Pump operation fluctuates between at 61% to full design BEP
    - Due to the plant start-up schedule, changing to a different pump/impeller design was not possible.

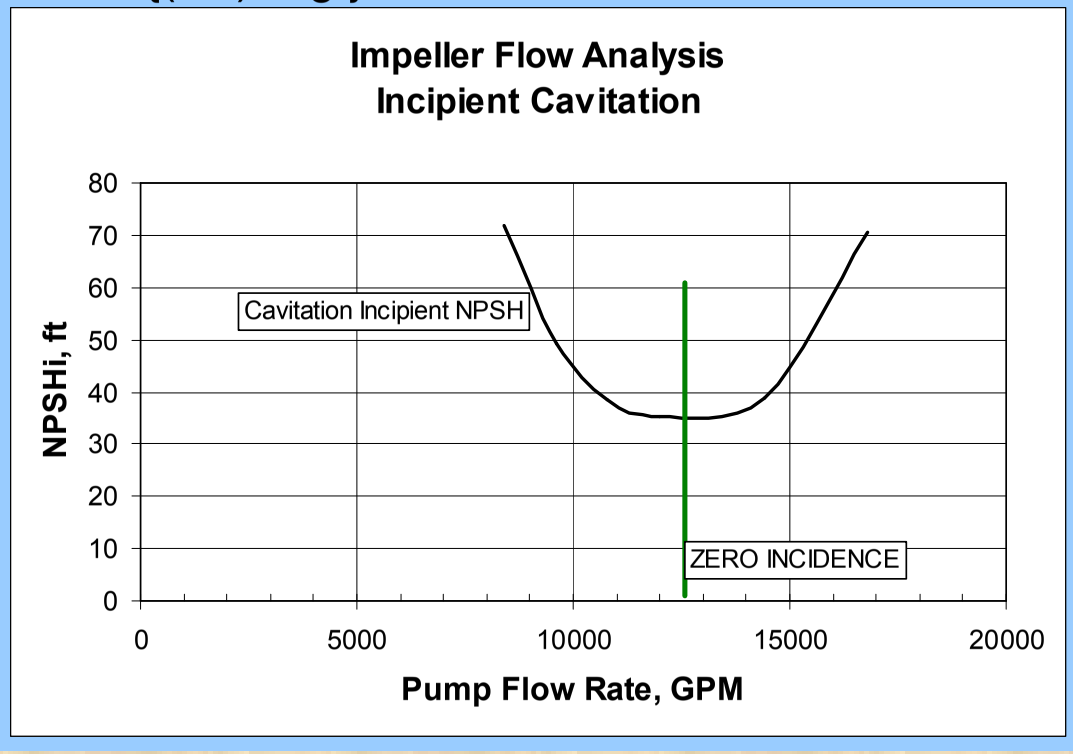
HYDRAULIC ANALYSIS OF THE IMPELLER

- FLOW ANGLE OF ATTACK CALCULATION
  - IMPELLER SUCTION EYE AREA
    - MERIDIONAL VELOCITY IS CALCULATED
  - IMPELLER EYE DIAMETER
    - EYE PERIPHERAL VELOCITY IS CALCULATED
  - BASED ON DESIGN ANGLE OF THE IMPELLER VANE, ANGLE OF ATTACK PLOT IS GENERATED.



HYDRAULIC ANALYSIS OF THE IMPELLER

- INCIPIENT CAVITATION NPSH CALCULATION
  - BASED ON UPSTREAM FLOW VELOCITY
    - ABSOLUTE VELOCITY BASED ON MERIDIONAL AND PERIPHERAL VELOCITIES
  - INCIPIENT CAVITATION NUMBER, δ, BASED ON ANGLE OF ATTACK
  - $NPSHi = \delta * \{(Va)^2/2g.\}$

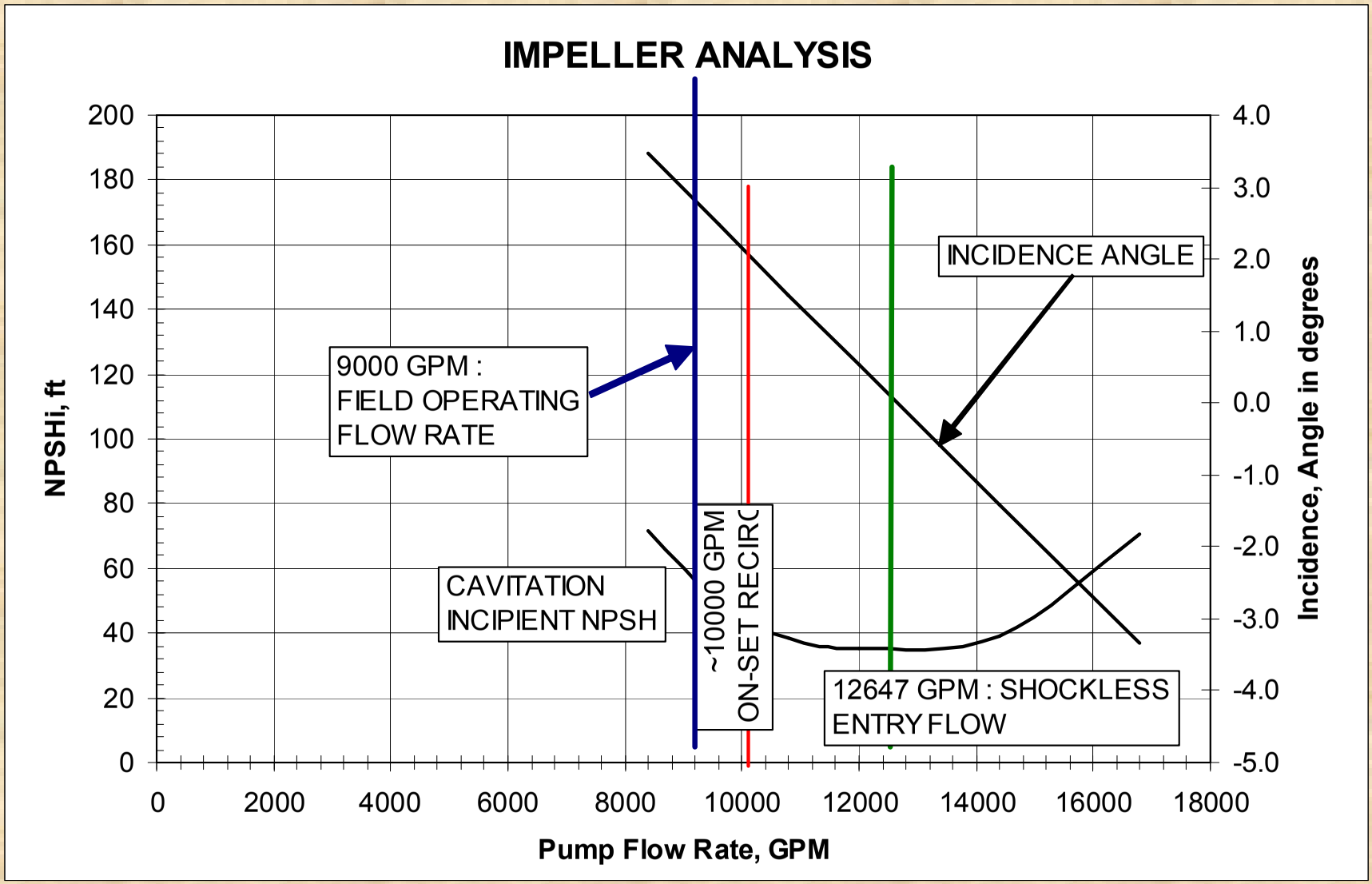


HYDRAULIC ANALYSIS OF THE IMPELLER

- SUCTION RECIRCULATION
  - Flow reversal within the impeller channels
    - Based on impeller geometry
    - On-set can be calculated based on:
      - Impeller eye diameter
      - Impeller vane angle at the inlet
      - Shockless entry flow rate
      - OR relationship based on NPSHr 3% curve

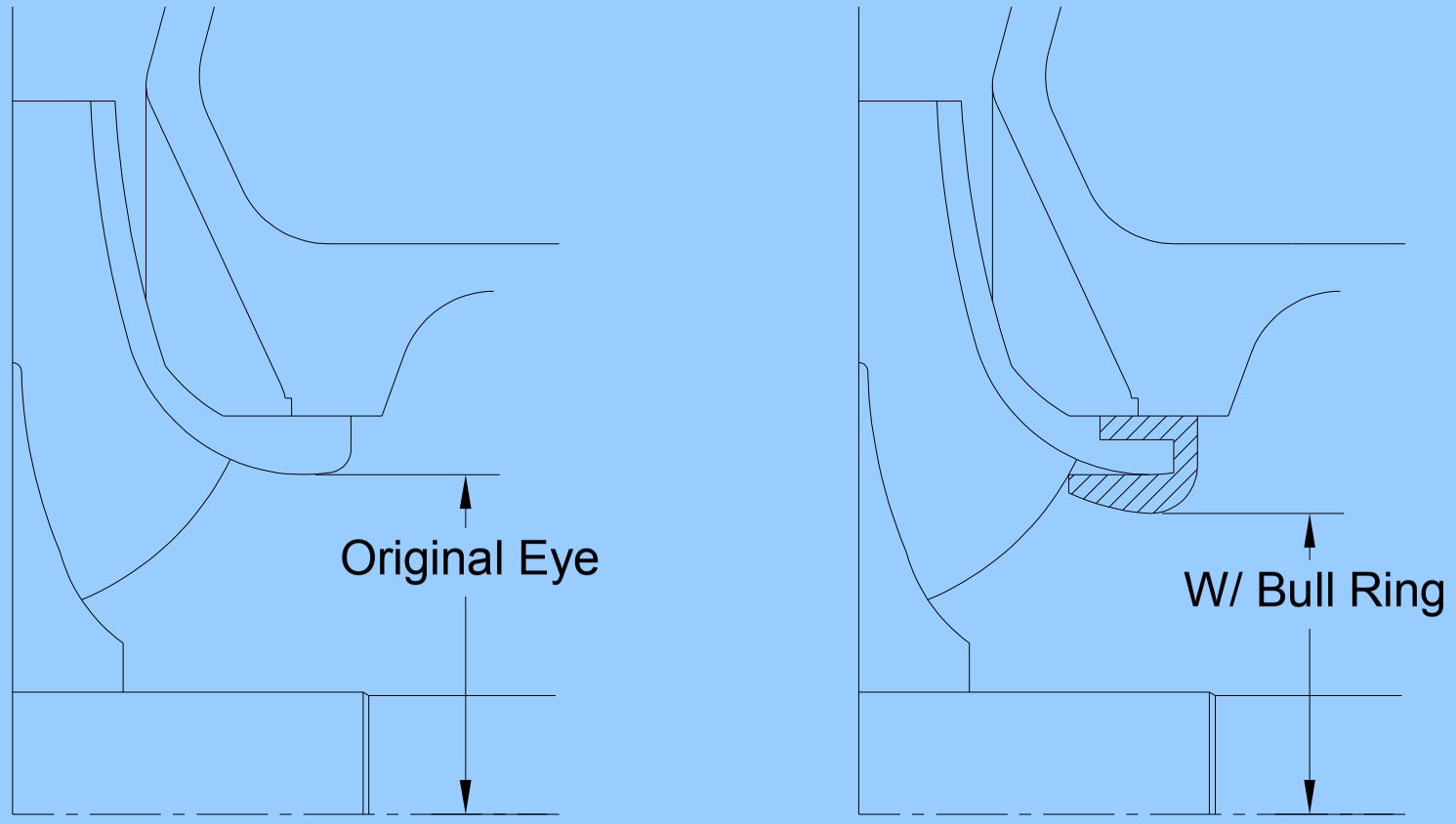
1	Calculation of Shockless Entry Flow			
	Eye Area=	282.1248	in^2	
	Ue =	77.6	ft/sec	
	Be =	10.5	0.185	(radians)
	n=	1778	rpm	
	De =	10	in	
	R2 =	3.5	in	
	Dh =	3.5	in	
	NPSHr =	28	ft	
	NPSHa =	30	ft	
	specific gravity =	1		
	Shockless Entry Flow, Qse=	**12647**	gpm	(total-double suction)
1.1	Suction Recirculation Flow	Method 1		
	Csr =	11.381	If Be is less than 9.5 use Be=9.5	
	Suction Recirc Flow, Qsr =	**10003**	gpm	
1.2	Suction Recirculation Flow	Method 2		
	NPSH 3% @ Qse =	28		
	Ss =	16427		
	Qsr =	**9123**	**gpm**	

HYDRAULIC ANALYSIS OF THE IMPELLER W/ VIBRATION PROBLEMS

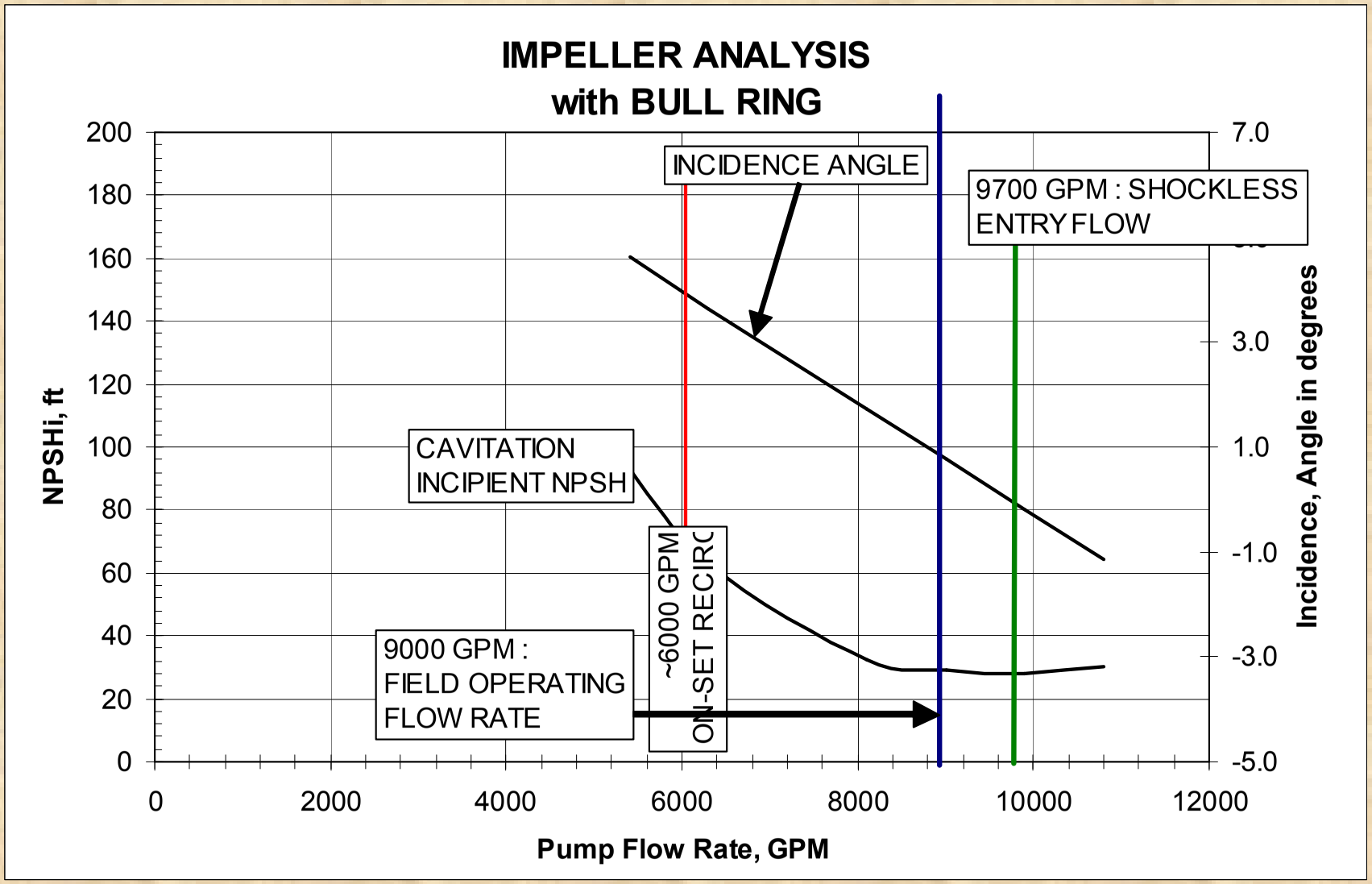


HYDRAULIC RETROFIT DETAILS

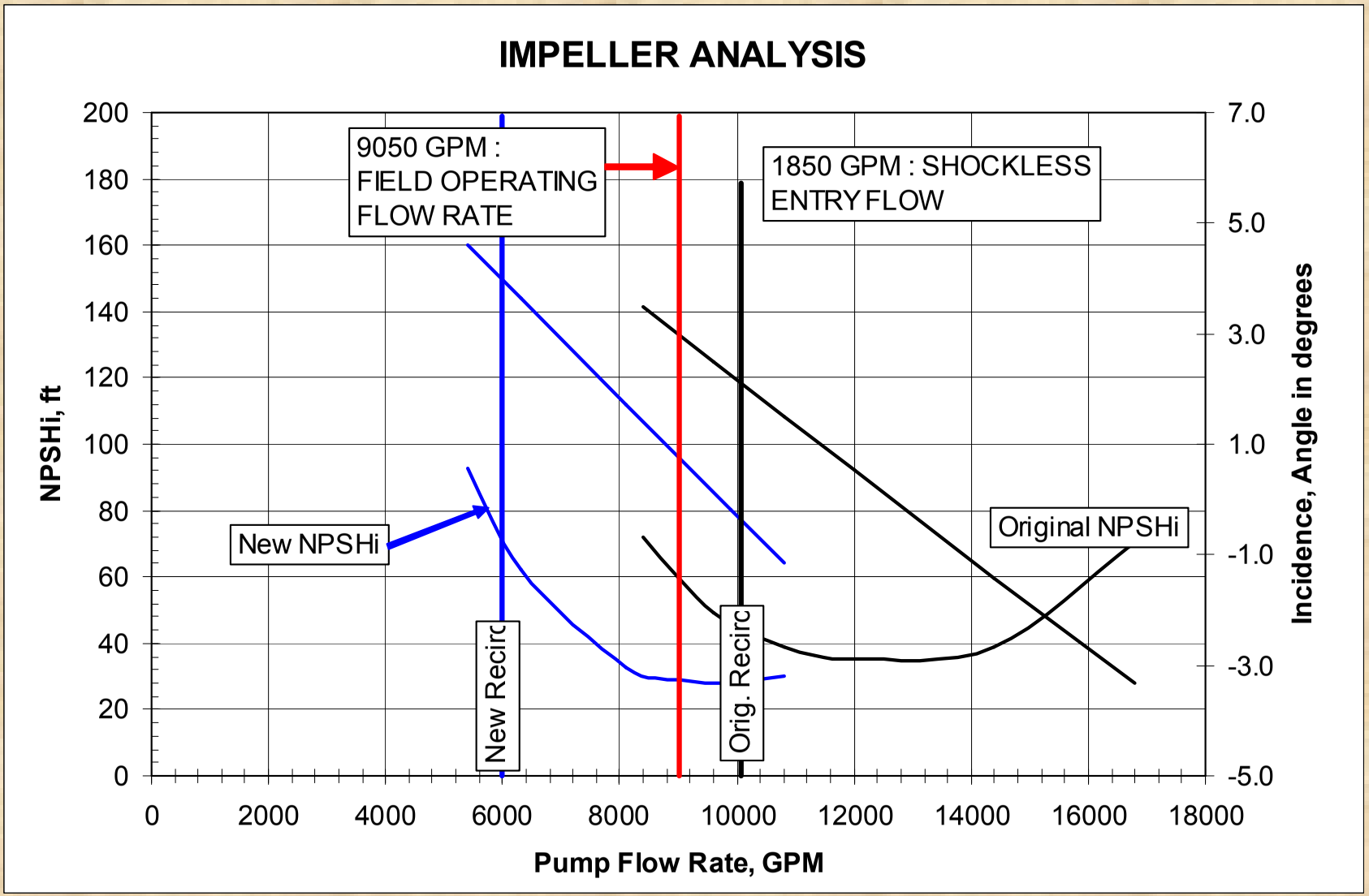
BULL RING INSTALLATION



HYDRAULIC ANALYSIS OF THE IMPELLER WITH THE RETROFIT



HYDRAULIC ANALYSIS OF THE IMPELLER DIRECT COMPARISON



FINAL FIELD VIBRATION LEVELS

VIBRATION MEASUREMENTS AFTER BULL RING INSTALLATION	
Pump A	
Location, Pump Bearing Housing	Overall Readings, in/sec
Out Board Horizontal	0.189
Out Board Vertical	0.180
In Board Horizontal	0.163
In Board Vertical	0.146
Axial	0.085
Pump B	
Location, Pump Bearing Housing	Overall Readings, in/sec
Out Board Horizontal	0.192
Out Board Vertical	0.192
In Board Horizontal	0.185
In Board Vertical	0.158
Axial	0.120

FINAL FIELD VIBRATION LEVELS

VIBRATION READINGS			
INITIAL VIBRATION MEASUREMENTS		FINAL READINGS	
Pump A		Pump A	
Location, Pump Bearing Housing	Overall Readings, in/sec	Location, Pump Bearing Housing	Overall Readings, in/sec
Out Board Horizontal	0.337	Out Board Horizontal	0.189
Out Board Vertical	0.474	Out Board Vertical	0.180
In Board Horizontal	0.258	In Board Horizontal	0.163
In Board Vertical	0.417	In Board Vertical	0.146
Axial	0.119	Axial	0.085
Pump B		Pump B	
Location, Pump Bearing Housing	Overall Readings, in/sec	Location, Pump Bearing Housing	Overall Readings, in/sec
Out Board Horizontal	0.380	Out Board Horizontal	0.192
Out Board Vertical	0.390	Out Board Vertical	0.192
In Board Horizontal	0.248	In Board Horizontal	0.185
In Board Vertical	0.338	In Board Vertical	0.158
Axial	0.125	Axial	0.120

CONCLUSION

A FIELD VIBRATION PROBLEM WAS SOLVED BY A SIMPLE HYDRAULIC FIX

- FIELD OPERATING CONDITION WAS OBTAINED.

- DETAILED HYDRAULIC ANALYSIS WAS PERFORMED TO DESIGN THE BULL RING.

- THE HYDRAULIC MODIFICATION WAS DONE QUICKLY, WITH MINIMUM INTERRUPTION TO THE PROJECT SCHEDULE .

- THE PUMP IMPELLER WITH THE BULL RING NOW OPERATES IN THE OPTIMUM DESIGN FLOW RATE.

- VIBRATION WAS REDUCED TO ACCEPTABLE LEVELS

- THE PUMPS HAVE BEEN OPERATING WITHOUT PROBLEMS SINCE 2002.

END OF PRESENTATION

THANK YOU FOR YOUR ATTENTION