

# Mechanical Vibration Testing Reciprocating Pumps

Zach Kokel

Pump Engineering Manager  
FMC Industries Inc.  
Stephenville, TX, USA

James (B.J.) Dyck

Facilities Engineer  
Chevron  
Lafayette, LA, USA

26<sup>th</sup> International Pump Symposium

# Condensate Injection Recip Pump

- Specific gravity : 0.44
- Vapor pressure : 554.7PSIA
- Discharge Pressure : 5500 PSIA
- Speed : 240 RPM
- Quintuplex Design

Pump was purchased with a witnessed vibration test under suppliers vibration specification.

Specification's vibration acceptance level was 0.25 in/sec for the pump and 0.30 in/sec for guards and spools.

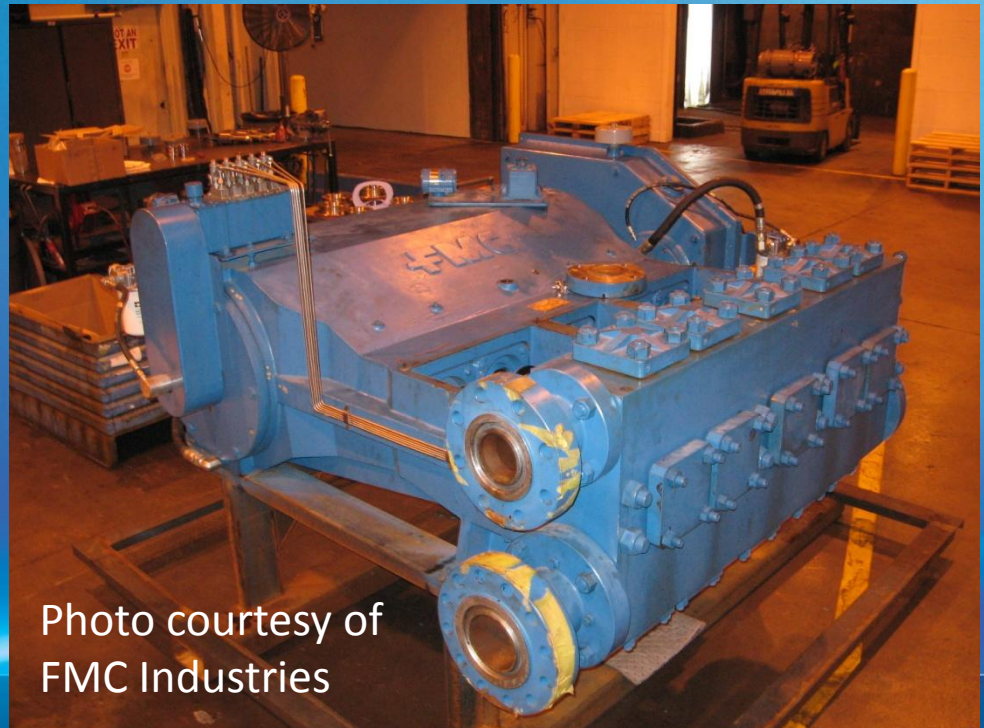


Photo courtesy of  
FMC Industries

# Which Vibration Standard Applies?

## ● Available Standards

### ● Balmac

- Equipment category definition is vague.
- Acceptable vibration allowance varied by category.

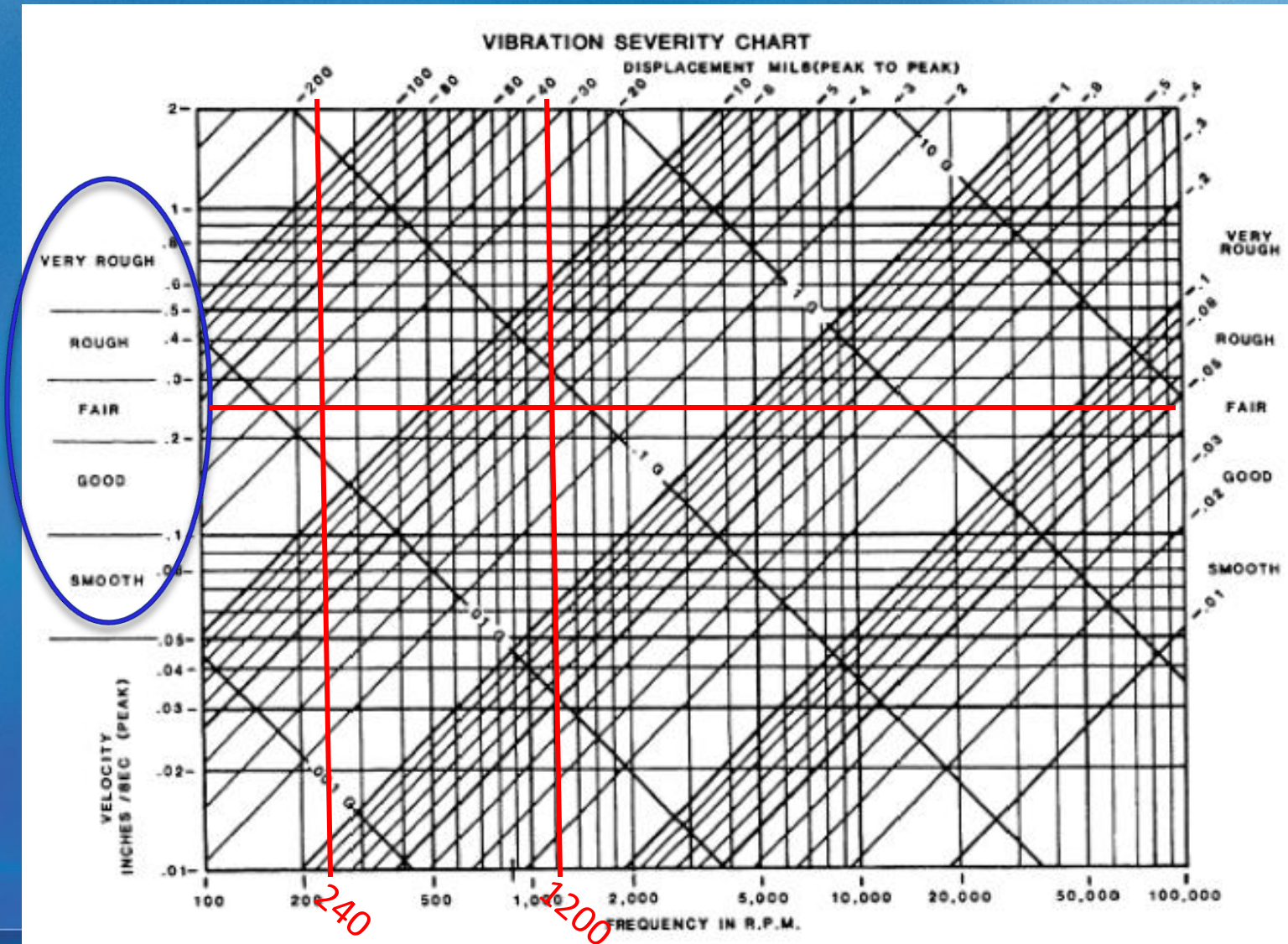
### ● ISO 108016-6:1995

- Equipment category definition is vague.
- Acceptable vibration allowance varied by category.

### ● API 674, 2<sup>nd</sup> Edition

- Does not specify any vibration acceptability tolerances.

# Vibration Conversion Chart



# ISO 10816-6 Vibration Limits

ISO 10816-6:1995(E)

© ISO

Table A.1 — Vibration classification numbers and guide values for reciprocating machines

Vibration severity grade	Maximum values of overall vibration measured on the machine structure			Machine vibration classification number						
	Displacement $\mu\text{m}$ (r.m.s.)	Velocity $\text{mm/s}$ (r.m.s.)	Acceleration $\text{m/s}^2$ (r.m.s.)	1	2	3	4	5	6	7
	Evaluation zones									
1,1	17,8	1,12	1,76							
1,8	28,3	1,78	2,79	A/B						
2,8	44,8	2,82	4,42		A/B					
4,5	71,0	4,48	7,01			A/B				
7,1	113	7,07	11,1	C				A/B		
11	178	11,2	17,6		C					A/B
18	283	17,8	27,9			C				
28	448	28,2	44,2				A C			
45	710	44,8	70,1	D				C		

## Key to zones

- A: The vibration of newly commissioned machines would normally fall within this zone.
- B: Machines with vibration within this zone are normally considered acceptable for long-term operation.
- C: Machines with vibration within this zone are normally considered unsatisfactory for long-term continuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.
- D: Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine.

NOTE — Vibration values for reciprocating machines may tend to be more constant over the life of the machine than for rotating machines. Therefore zones A and B are combined in this table. In future, when more experience is accumulated, guide values to differentiate between zones A and B may be provided.

# Balmac Vibration Reference

Class-1: Individual components, integrally connected with the complete machine in its normal operating condition. Small Electric Motors, Precision Machines, Turbines

Class-2: Medium size machinery without special foundations, rigidly mounted engines, or machines on special foundation. Gear Boxes, Pumps, M-G Sets, Fans

Class-3: Large prime movers mounted on heavy, rigid foundations. Compressors, Blowers, Hammer mills, Engines

Class-4: Large prime movers mounted on relatively soft, light-weight structures. Crushers, Reciprocating Machinery, Vibrating Conveyors

Vibration (ips)	Class-1	Class-2	Class-3	Class-4
0.01 ips	GOOD	GOOD	GOOD	GOOD
0.02 ips	GOOD	GOOD	GOOD	GOOD
0.03 ips	GOOD	GOOD	GOOD	GOOD
0.06 ips	FAIR	GOOD	GOOD	GOOD
0.08 ips	FAIR	FAIR	GOOD	GOOD
0.1 ips	<b>ROUGH</b>	FAIR	FAIR	GOOD
0.2 ips	N/A	<b>ROUGH</b>	FAIR	FAIR
0.4 ips	N/A	N/A	<b>ROUGH</b>	FAIR
0.6 ips	N/A	N/A	N/A	<b>ROUGH</b>
0.8 ips	N/A	N/A	N/A	N/A
1.0 ips	N/A	N/A	N/A	N/A

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# Baseplate Stiffness Effects



Photo courtesy of  
FMC Industries

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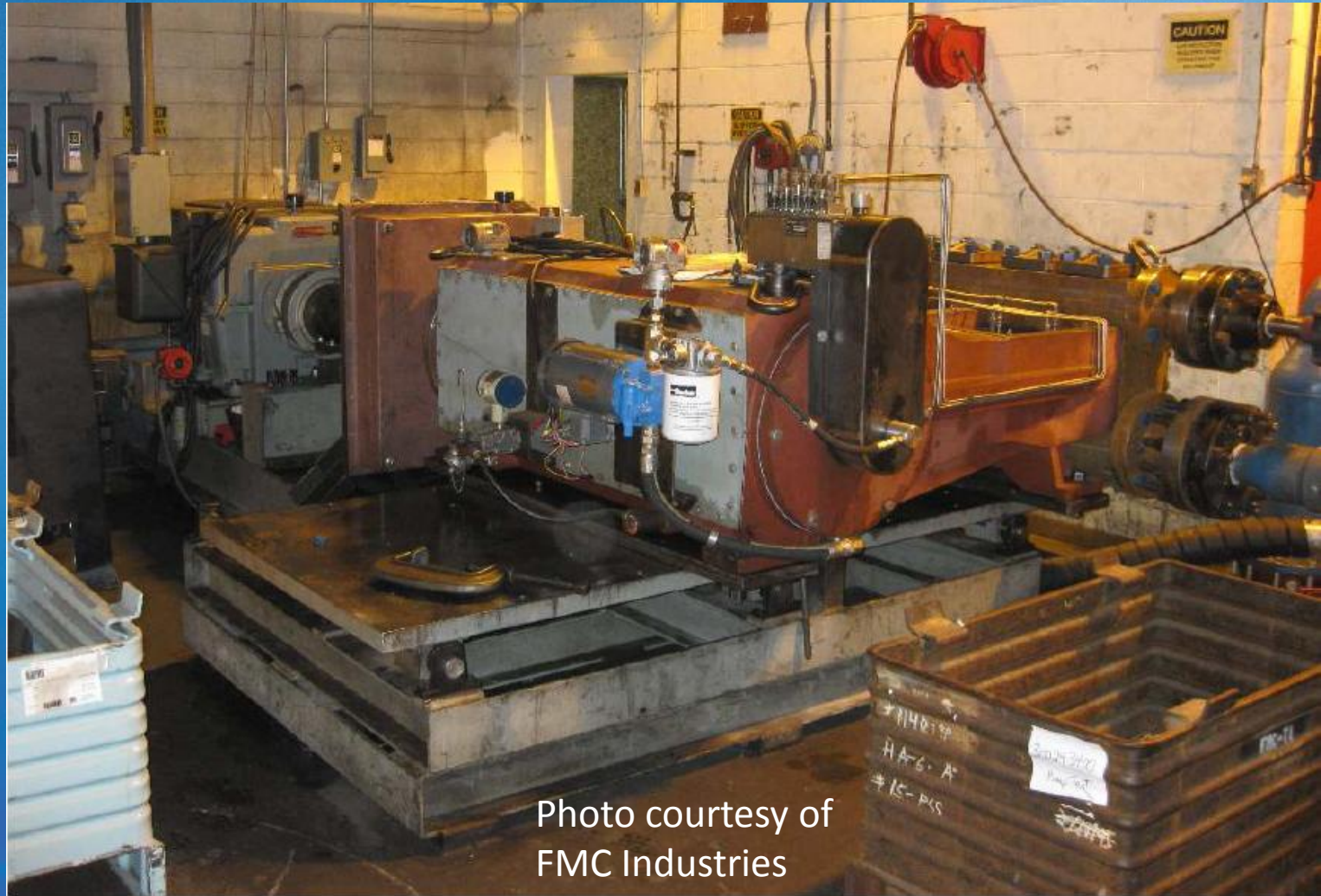


Photo courtesy of  
FMC Industries



# Baseplate Stiffness Effects



Photo courtesy of  
FMC Industries

# Bump Test

500 HP Test Stand – Impact Test Data

Frame 1Z

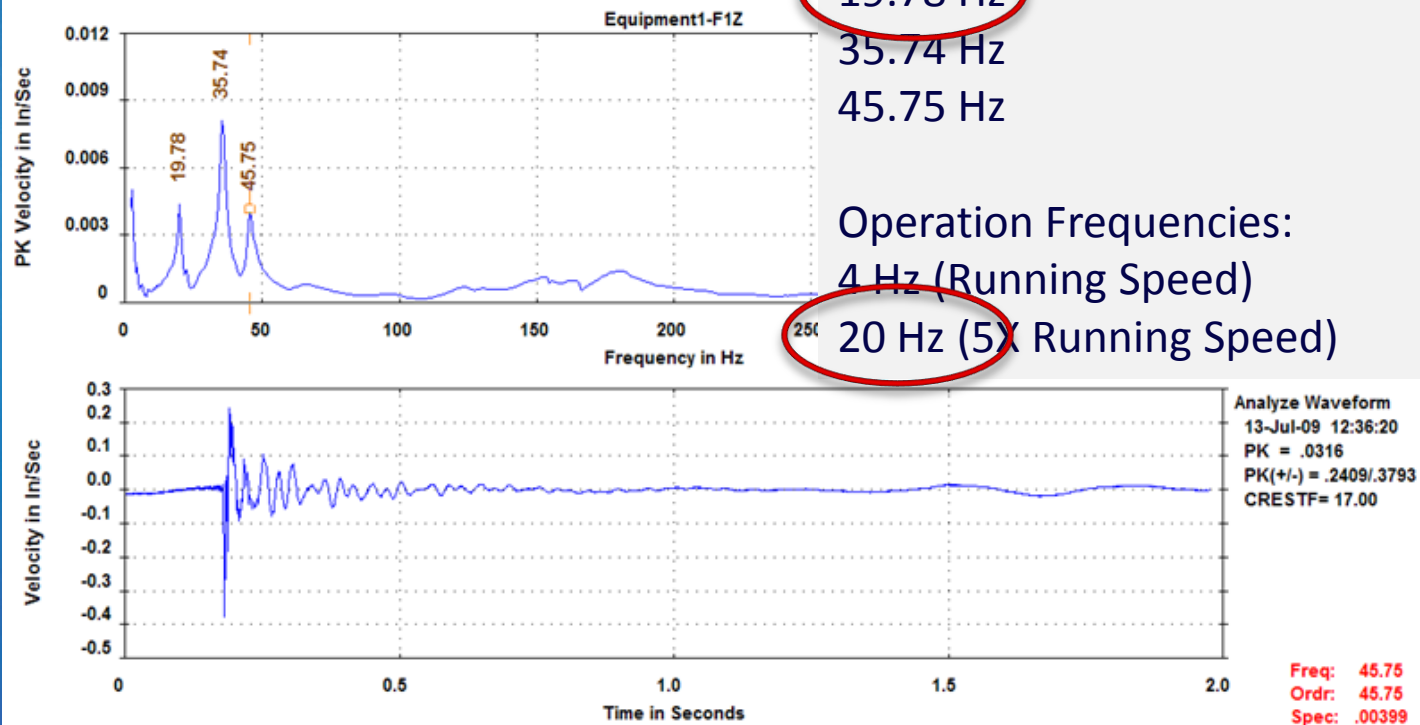


Photo courtesy of FMC Industries

# Driveline Vibration



# Driveline Vibration

## 500 HP Test Stand Piston Pump Spectrums & Waveforms

### 1X Pump Drive Bearing 1X

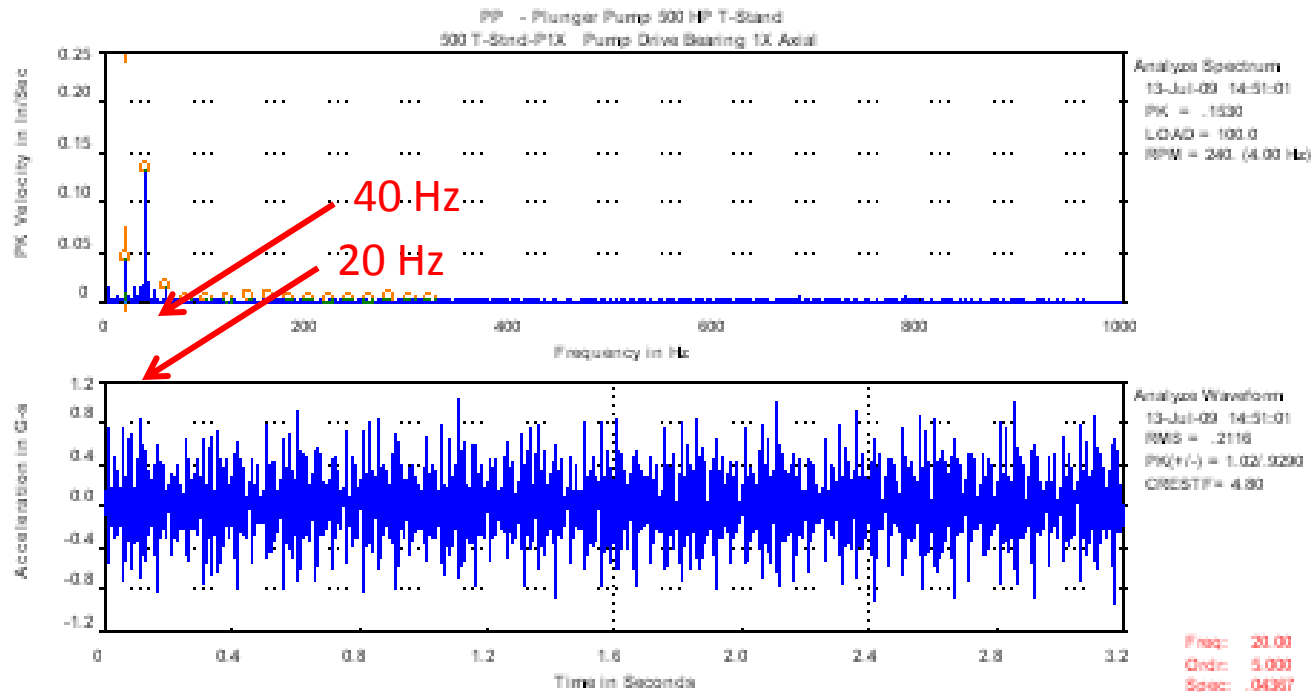
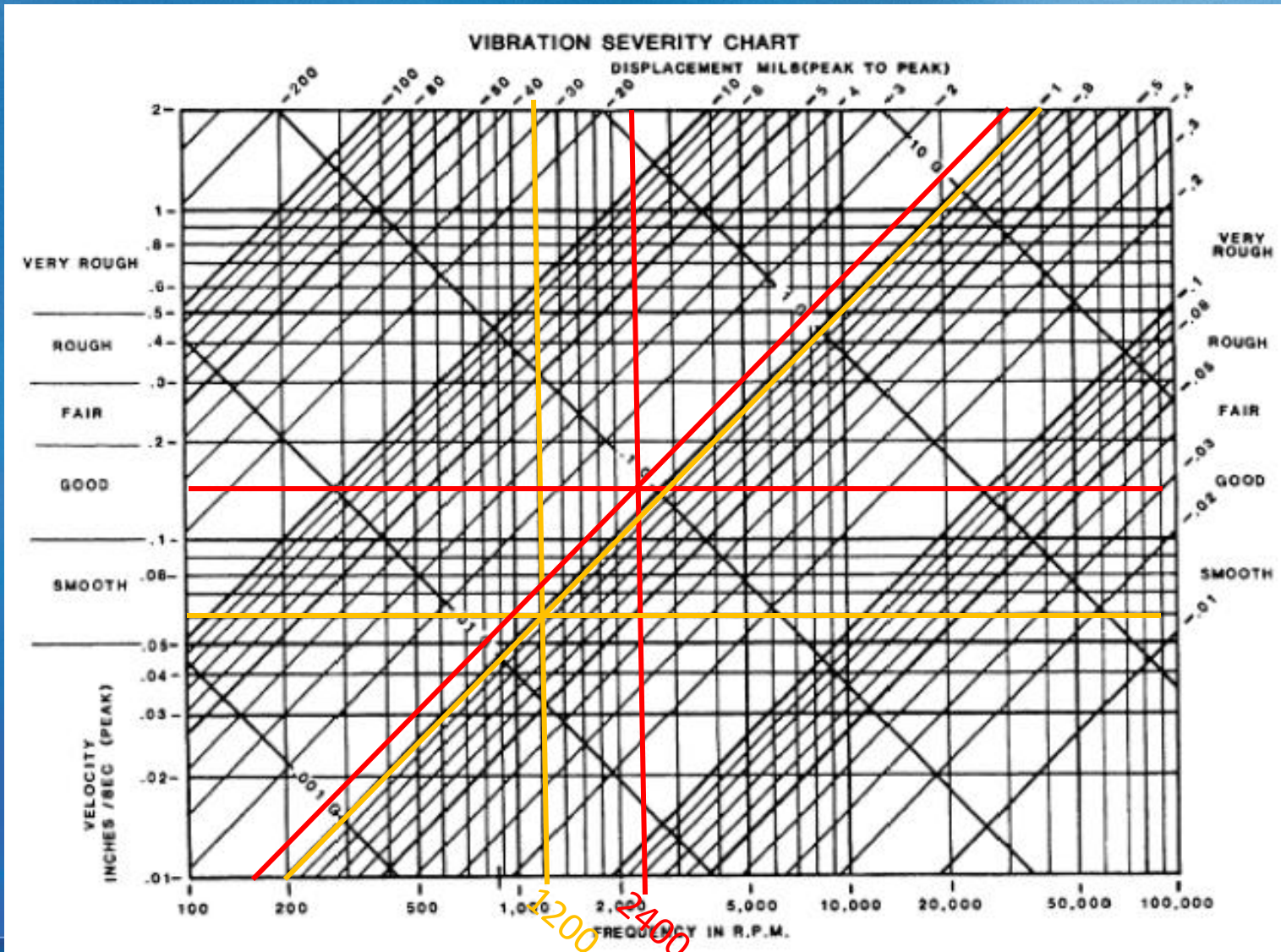


Photo courtesy of FMC Industries

# Vibration Conversion Chart



# Accepted Vibration Test

- Pump passed
  - Maximum vibration recorded
    - 0.33 in/sec
  - Purchasers legacy vibration requirement
    - 0.40 in/sec

# Lessons Learned

- Recip pump vibration typically considered fluid induced, mechanical vibration must also be considered
- Vibration limits need to be set based on:
  - Fluid being pumped
  - Size of pump
- Reduce all external vibration influences
  - Rigid base
  - Direct drive line (w/flexible coupling)

# Current Operation

- Pump completed final testing in January of 2010
- Pump is not installed and there is no further information on field performance with piping and pulsation dampeners.



Thank you!

QUESTIONS?

