Gas Field Policy 2: Compressor Performance Policy

It is the responsibility of the Authorized Packager to quote and sell D-R compressors only for conditions of service that are within the limits of the compressor. It is also the responsibility of the Authorized Packager to design and manufacture their package so that the D-R compressor is protected from having any of its limitations exceeded, at any time, while operating at any normal or upset condition (including relief valve discharge pressure).

Orders can be accepted only if no compressor limitation outlined below is exceeded at any time except for those specifically approved by D-R HSRC Marketing.

This GFP has consolidated information previously on (5) different GFP to place all compressor performance issues in one document.

COMPRESSOR PERFORMANCE LIMITATIONS

D-R HSRC Marketing will review the guarantee point performance and any off-design performance, of new D-R compressors, calculated using the latest version of the D-R HSRC sizing/performance program, during the quote stage or at the time of the order, at no additional charge. D-R HSRC Marketing will advise the Packager of any limitations exceeded, special construction required, or any other problems or concerns. As a part of this review, D-R HSRC Marketing will check the gas and combined rod loads at the suction and discharge pressures that result in the highest rod loads, adding the margins listed below to the discharge pressure to allow for a reasonable margin between the compressor load limits and protective devices.

<table>
<thead>
<tr>
<th>Stage Discharge Pressure (PSIG)</th>
<th>Margin Above Discharge Pressure</th>
<th>Stage Discharge Pressure (PSIG)</th>
<th>Margin Above Discharge Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>-14.7 to 150</td>
<td>15 PSI</td>
<td>2501 to 3500</td>
<td>8%</td>
</tr>
<tr>
<td>151 to 2500</td>
<td>10%</td>
<td>3501 to 6000</td>
<td>6%</td>
</tr>
</tbody>
</table>

Based on the various criteria contained herein, D-R HSRC Marketing must be satisfied that neither the flange gas load nor the combined rod load exceeds the Maximum Allowable Operating Rod Load (MAORL) limit of the compressor at any time.

Additional criteria and limitations to be considered when reviewing compressor performance are as follows:

- Maximum Allowable Working Pressure (MAWP) shall not exceed that as defined by the cylinder rating.
- Horsepower/Throw shall not exceed that defined by the frame (except as specifically approved by DR HSRC Marketing)
- Discharge Volumetric Efficiencies shall not fall below 10%.
- Adiabatic Discharge Temperature (for pressures less than 4000 PSIG) shall not exceed 300°F (149°C). For pressures greater than 4000 PSIG, see additional information herein.
- Predicted Actual Discharge Temperatures shall not exceed 350°F (177°C).
- Rod Reversal shall exceed 40°.
- The ratio of tension load to compression load or vice-versa, shall exceed 20%.
The recommended maximum allowable RPM of compressors operating at high discharge pressure and/or heavy mole weight gases can be found on the following curves. See Figures 1 & 2.

1. Use the discharge pressure (psig) to determine the maximum allowable adiabatic discharge temperature.

2. Divide the Molecular Weight (MW) by the lowest encountered compressibility (Z) to determine MW/Z.

3. Find the “Maximum Speed Factor” limitation from Figure 1 based on both the Pressure (top curve) and MW / Z (bottom curve), and use whichever is lower.

4. Find the Maximum Allowable Speed for a frame from Figure 2 using the "Maximum Speed Factor".

Example 1 - For a discharge pressure of 4000 psig and MW/Z of 20, the Maximum Speed Factor is 12 and the maximum allowable adiabatic discharge temperature is 300 degree F. For a 6" stroke frame the Maximum Allowable Speed is 1200 RPM.

Example 2 - For a discharge pressure of 2000 psig and a MW/Z of 50, the Maximum Speed Factor is 9 and the maximum allowable adiabatic discharge temperature is 300 degree F. For a 4" stroke frame the Maximum Allowable Speed is 1350 RPM.

Example 3 - For a discharge pressure of 6000 psig and a MW/Z of 20, the Maximum Speed Factor is 9 and the maximum allowable adiabatic discharge temperature is 270 degree F. For a 3.5" stroke frame the Maximum Allowable Speed is 1543 RPM.

Any application outside these recommended limits should be approved by D-R HSRC Marketing prior to quoting.

SPECIAL APPLICATION REVIEW

D-R HSRC Marketing should also review and approve any applications with any of the following parameters before Authorized Packagers quote them:

- Discharge pressures 6000 PSIG or greater.
- Differential pressures greater than 3000 PSIG for a given stage.
- Predicted actual discharge temperatures of 325° F or greater.
- All Non-Lubricated applications.
- Heavy gas applications (ie MW >40).
- Applications involving process gases i.e., hydrogen, oxygen, chlorine, carbon monoxide, etc.
Speed Restrictions for Separable Compressors

WHERE:  
MW = MOLECULAR WEIGHT
Z = LOWEST ENCOUNTERED COMPRESSIBILITY FACTOR

![Diagram showing speed restrictions for separable compressors](image_url)

Figure 1
Speed Conversion

\[ \text{Speed} = \frac{600 \times \text{Speed Factor}}{\text{Stroke}} \]

3.5° Stroke
4.0° Stroke
4.5° Stroke
5.0° Stroke
5.5° Stroke
6.0° Stroke
7.0° Stroke
7.25° Stroke
8.5° Stroke

Maximum Speed Factor

Figure 2
CAPACITY CONTROL OPTIONS

Acceptable methods of capacity control are listed below:

A. SPEED CONTROL - The preferred method of reducing compressor capacity is speed reduction, where variable speed drivers are employed.

B. FLOW REDUCTION BY ADDING CLEARANCE - Clearance may be added to the head end of cylinders with manual variable-volume clearance pockets, or to the head end with pneumatic fixed-volume clearance pockets, clearance bottles, and/or split-valve-yokes. Any time clearance is added, care must be taken to insure that the discharge volumetric efficiency for any cylinder end is ten percent (10%) or more, for proper valve operation and so that temperature pyramiding does not occur. With special "Pipeline" or "Storage" cylinders, pneumatic fixed volume clearance pockets may be also added to crank end.

C. TOTAL UNLOADING OF CYLINDER ENDS - The preferred method is suction valve removal. Normally the head end is unloaded first to avoid cross-head non-reversal problems. The minimum number of degrees of rod reversal (40 degrees) and ratio of minimum combined load to maximum combined load (>20 percent) must be met. This must be checked throughout the operating RPM range.

D. TOTAL CYLINDER END UNLOADING BY PNEUMATIC UNLOADERS - When it is not possible to shut down, vent and purge the compressor and system to remove the suction valve(s), pneumatically-operated "plug" or "port" unloaders may be furnished. (Finger type unloaders are no longer recommended.) As above, the head-end of the cylinder must be unloaded before the crank-end, unless otherwise approved by D-R HSRC Marketing, after a review of the entire operating range of the compressor. When end unloading is required, please consult D-R HSRC Marketing for guidance and approval. Normally cylinders should not be completely unloaded with pneumatic unloaders except for very brief periods at startup. Pneumatic unloaders reduce valve lift areas and decrease cylinder efficiency. They should be used only when absolutely required.

E. HORSEPOWER LIMITS OF UNLOADED CYLINDERS - When a cylinder end is totally unloaded by any method, the brake horsepower per throw limitation (at the operating RPM) is reduced fifty percent (50%).

F. DRESSER-RAND RECOMMENDS THAT A PULSATION STUDY OF THE PIPING SYSTEM BE PERFORMED WHENEVER IT IS ANTICIPATED THAT THE COMPRESSOR WILL BE OPERATED WITH ANY CYLINDER END(S) TOTALLY UNLOADED BY ANY METHOD.

G. BYPASS - A bypass from final discharge to initial suction, through a throttling valve, may be used either as a sole means of capacity control or, more commonly, in conjunction with other methods. Since the cooling effect of expansion across a throttling valve is normally not enough to remove the heat of compression, capacity control using a throttling bypass usually requires taking gas downstream of the aftercooler, or providing cooling for the bypass, to prevent heat buildup through the system. The opposite case of too much cooling across the valve can also be a problem because of a potential for freezing of the throttling valve due to localized cooling due to expansion. Maximum differential across the valve will depend on operating temperature, ambient temperature, and gas composition. Steps to prevent freeze-up include multi-step throttling and heat tracing of the valve. Please note: Any cooled bypass, whether for throttling or for start-up, should be returned to the inlet side of the unit upstream of the separator element due to the potential of entrained moisture being carried into the inlet gas stream.
PERFORMANCE GUARANTEE POLICY

Dresser-Rand will guarantee the design point performance of its new (unused) compressors, when the performance has been reviewed and approved by D-R HSRC Marketing in accordance with procedures outlined above. This review affords Dresser-Rand the opportunity to detect possible input errors, and / or the exceeding of compressor design limitations which may have been overlooked during the proposal stage.

Dresser-Rand guarantees the compressor flow and horsepower, independently, within a tolerance of ±3%, subject to the following conditions:

1. All cylinders must be double-acting. (Single-acting cylinders may be used for off-design conditions, as outlined above).

2. The compressed gases must be delivered to the suction flange of each cylinder with 99.9%, by weight, of all entrained solid and liquid particles, ten microns and larger, removed.

3. For multi-stage compressors, unless otherwise specified, the compressor brake horsepower will be calculated using the same suction temperature to each stage of compression.

4. Performance falls within RPM guidelines specified in above. If it falls outside the guidelines, guarantee tolerance becomes ±6%.

5. Suction pressure of all stages and/or services is higher than 10 PSIG. If pressure is less than 10 PSIG, guarantee tolerance becomes ±6%.

Any field performance test must be in accordance with the following:

1. The test must be performed in accordance with ISO 1217.

2. The test must be performed within 60 days of initial start-up.

3. The compressor owner shall ensure that all equipment is in "as-new" condition at the time of the test.

4. The extrapolation from guarantee point to actual test point, if necessary, will be done by Dresser-Rand, utilizing Dresser-Rand formulas and computer performance prediction programs. Suction and discharge pressures are measured at the respective compressor cylinder suction and discharge flanges.

5. A pulsation study of the process piping system must have been performed.

6. The compressor driver must have been performance tested at the driver manufacturer's factory.

7. The charges for Dresser-Rand servicemen, technicians and /or engineers, to verify the field testing procedures and / or results, if required, will be in accordance with the applicable service rates and conditions in effect at the time of the verification.
PERFORMANCE CURVE POLICY

1. Basic Performance Curves can be generated from the latest version of the D-R HSRC Sizing/Performance Program.

2. Special Performance Curves required to be generated by D-R HSRC Marketing will be priced upon request with full definition of the number and scope required. Pricing will depend upon the estimated engineering hours required to generate the Performance Curves. This applies to both new and used compressors.

3. As noted above, Dresser-Rand's policy is to guarantee only one Design Point performance on new compressors. Performance is not guaranteed on used compressors. All performance will be generated with the latest version of the D-R HSRC Sizing/Performance Program using the most accurate cylinder data available.