Flexware®

Turbomachinery Engineers

A Veteran & Employee Owned Small Business

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Lost Graphical Techniques

While all the computer power today can make things very easy and in fact make some near impossible things not only possible, but easy, there is still the issue of getting the computer set up with the proper information so it can do it's thing.

The following is a means of determining the numerical points for a compressor performance curve so they can be transferred to an Excel spread sheet for plotting operating points.

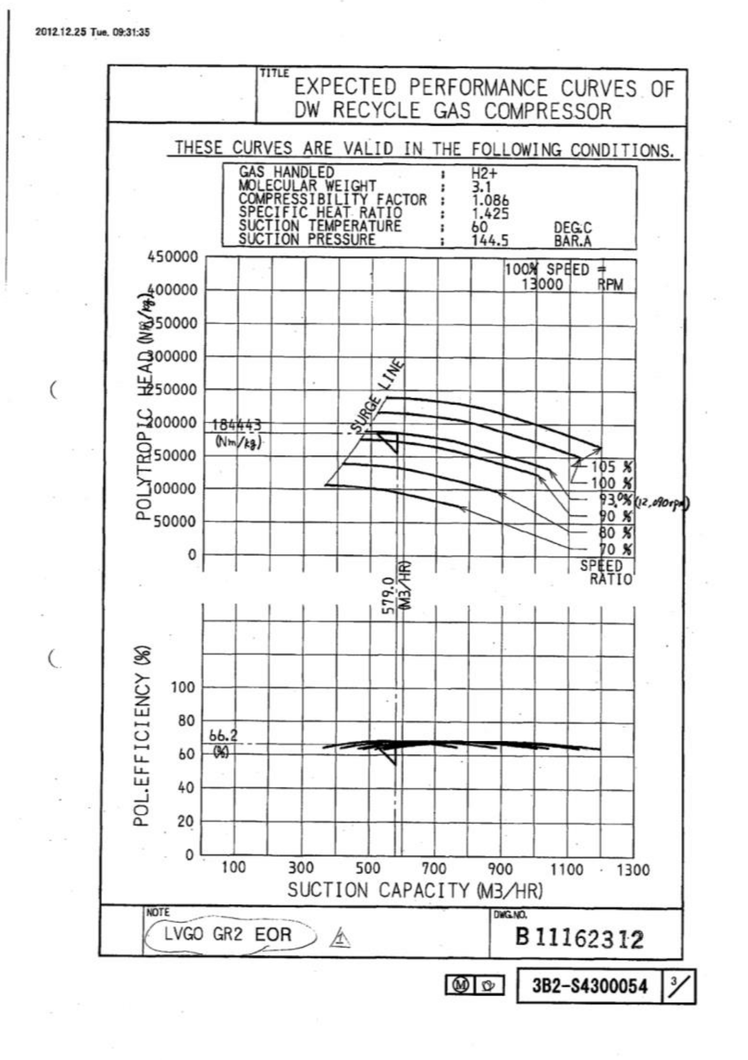

Figure #1. OEM Compressor performance curve.

So often you have a performance curve like the one in Figure #1 to work with. If the compressor is not too old, the OEM will provide you the points for generating the curve. However, all too often the compressor is old and even the OEM doesn't have the points and to regenerate the curve is a bit expensive.

You can scan the curve or just take a good photo with your cell phone. Then get it on your computer and blow it up.

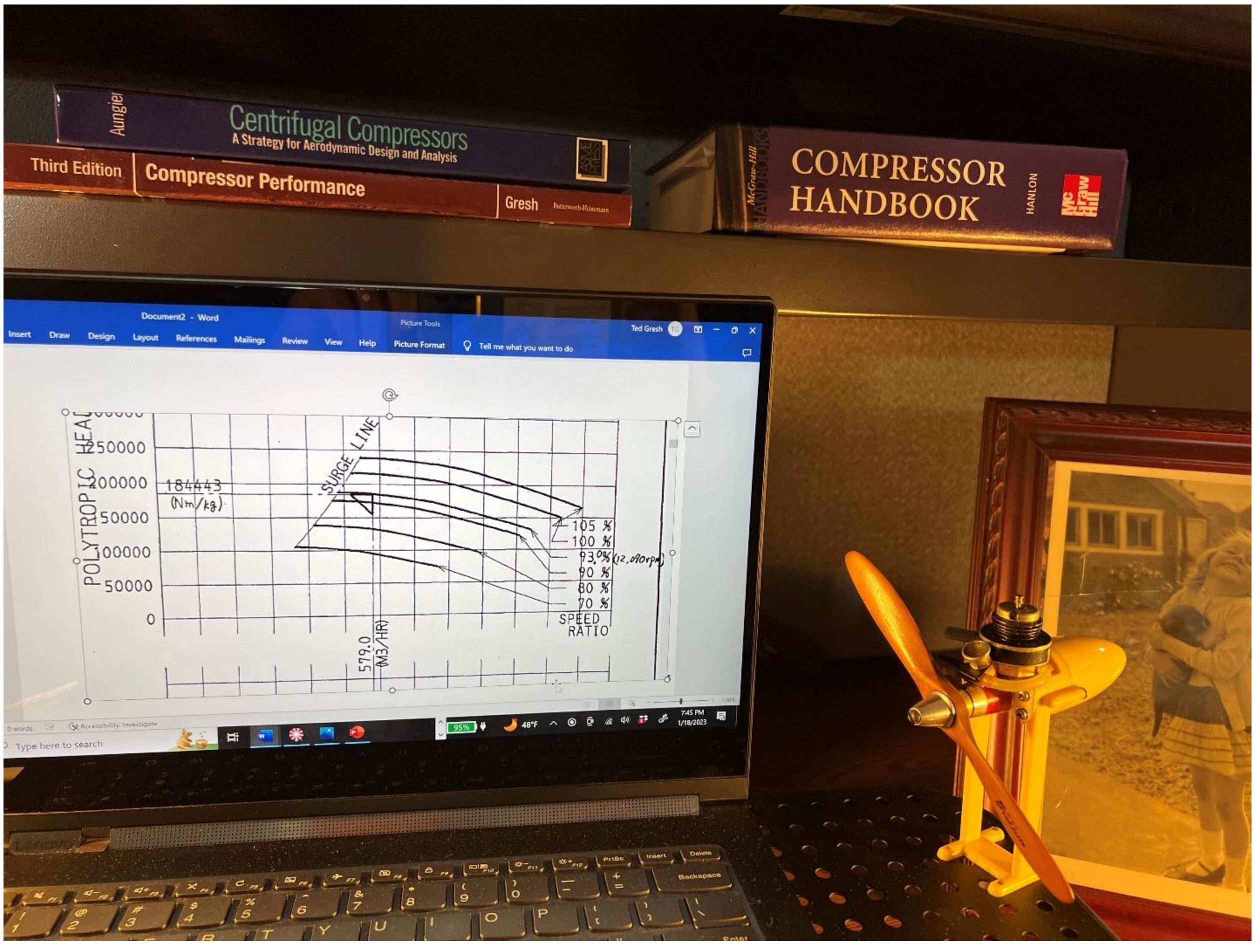

Figure #2. Get the performance curve on the computer screen and blow it up.

Once in digital form and enlarged, print it out and then you can accurately pick points off the curves.

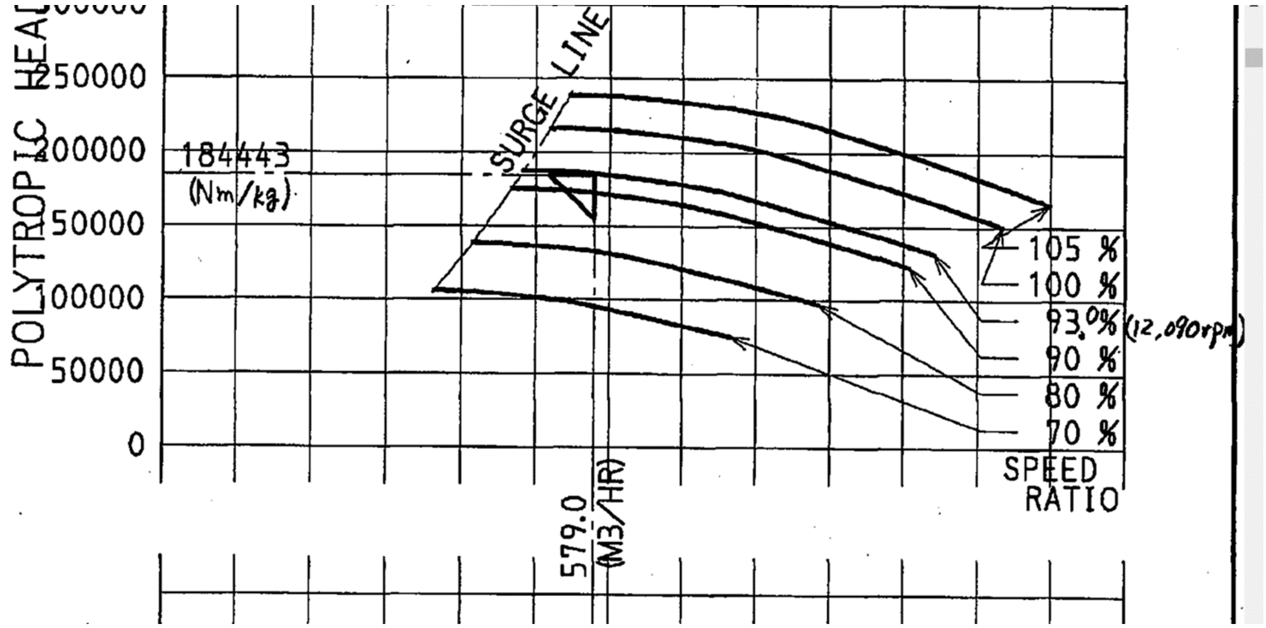

Figure #3. After the performance curve is expanded on your computer screen, do a print screen and paste to a word document. You may be able to expand it even further once on the Word document. Print a copy.

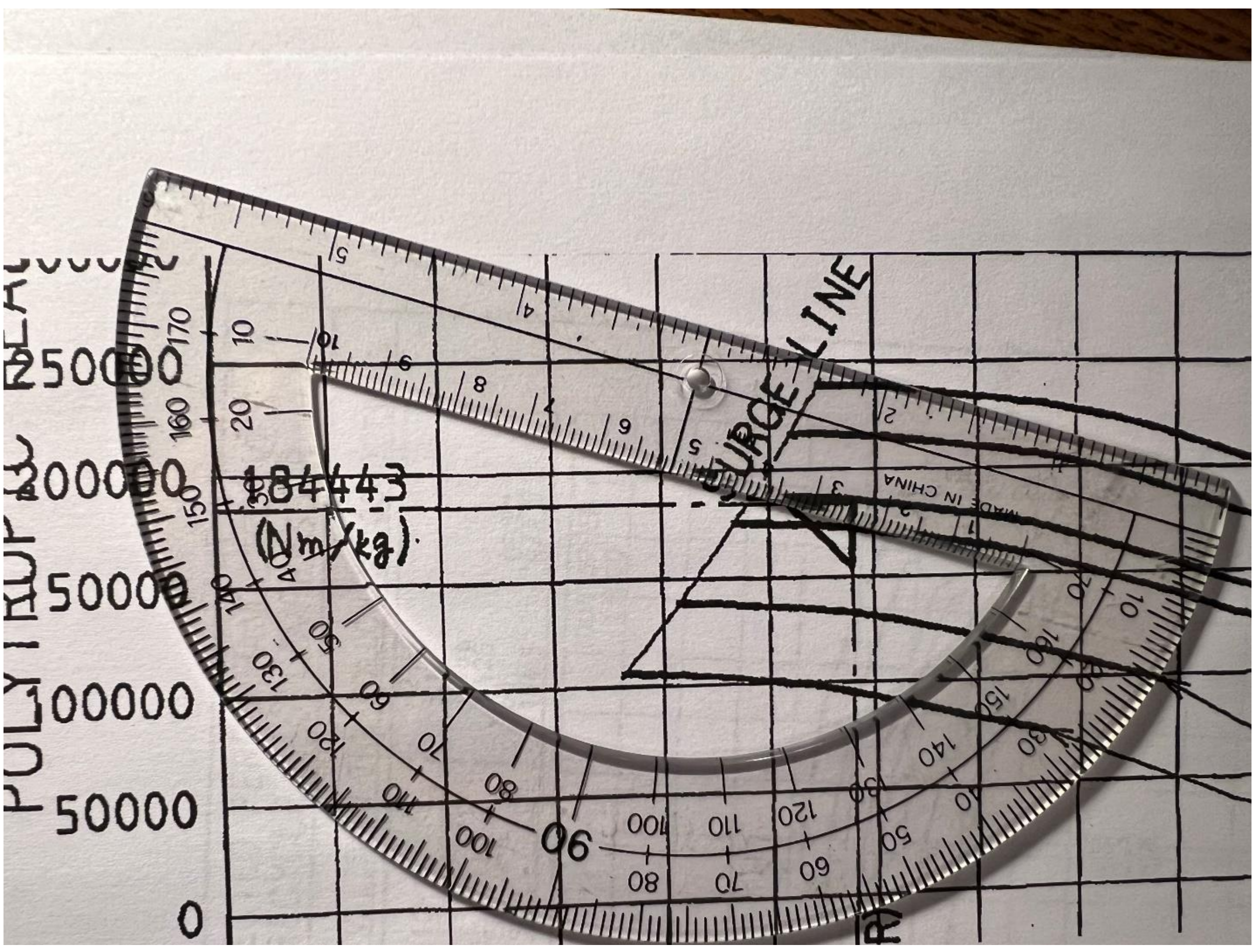

Figure #4. In this case the vertical axis is in increments of 5. In this photo I am trying to establish the head for the design speed at surge. It is near impossible to determine the value of the head at the surge point of the 100% speed line. Place a scale with increments of 5 or 10 at an angle on the performance curve. Shown here I placed the zero point of the scale on the 150,000 line and the 5 on the 200,000 line. Sliding the scale back and forth until the scale touched the end of the 100% speed line, I am able to accurately read the head value.

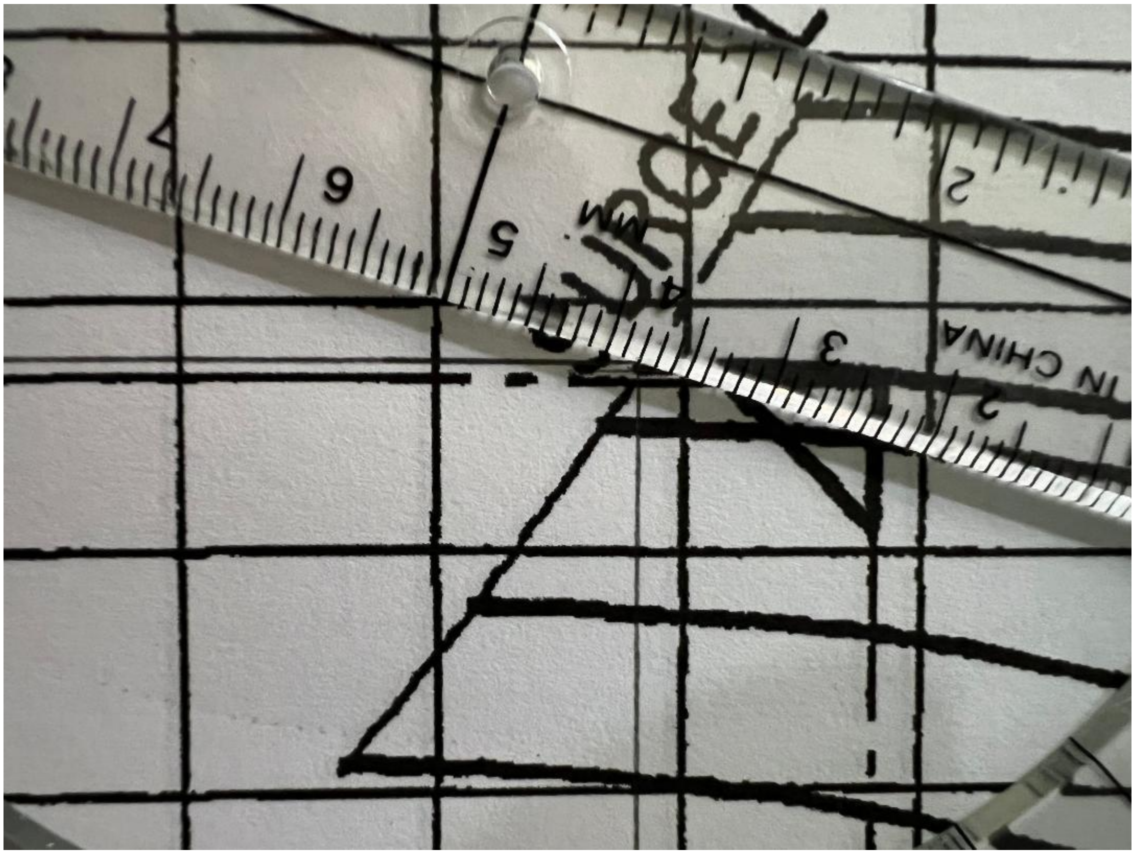

Figure #5. In this photo, once the scale has been properly positioned, I again take a photo of the setup with my phone and blow that up so I can better read the scale and determine the head is 188,000 Nm/kg. The scale reads 3.8. Adding this to 150000 gets you the 188,000.

Do this for 5 points on the 100% head curve for both the head and flow, then again for the efficiency. Once you have an accurate set of 5 points for the head and efficiency, enter them in the Excel spreadsheet to develop a curve you can use to plot the calculated head and efficiency values from your field test.

Gas Flex Excel Worksheet

Values from Manufacturer's Predicted Perfromance Curves

Instructions: **A**) Insert 5 data points (type over **underlined** values) from the compressor head and efficiency curves. Note that **point # 3 is the design point**. Use the curves for **design** speed. As in example, Point #1 is the lowest flow while point #5 is the highest. Enter values in order of increasing flow rate.

	Flow	Rated Efficiency	Rated Head	Rated Work
Point #1	475	64.0	188000	293750
Point #2	579	66.2	184443	278615
Point #3	700	68.0	179000	263235
Point #4	900	67.0	155000	231343
Point #5	1040	63.0	130000	206349

B) Insert the value for the **Design Speed**: 13000

Figure #6. Input values for the head and efficiency. The work values are automatically calculated. Point #1 is the surge point so it is always the lowest flow point. Point #5 is the choke point, the highest flow, end of the curve. Be sure to enter the flow values in order of increasing value. And don't forget to enter the speed for the curve, in this case 13,000 rpm.

Flex Live ® Compressor Field Test

01/16/2023 17:41:42 Version: 21.0.0.2

Description: C4101

Inputs	Units	Value
Inlet Pressure	kPa a	14,450
Inlet Temperature	°C	60.00
Inlet Flow	m³/hr	579.0
Discharge Pressure	kPa a	17,340
Discharge Temperature	°C	84.40

LVGO GR2 EOR

Gas Name	Mole Fraction
Methane	0.012199
Ethane	0.003100
Nitrogen	0.000000
Hydrogen Sulfide	0.000100
Hydrogen	0.969803
Cyclohexane	0.003800
N Butane	0.002500
Propane	0.004400
Iso Butane	0.002700
Water	0.001400

Gas Mixture	Units	Value
Molecular Weight		3.089
Critical Pressure	kPa a	1,609
Critical Temperature	°C	-229.5

Overall Results	Units	Value
Mass Flow	kg/hr	8,624
Gas Power	kW	610.9
Polytropic Work	N m/kg	255,016
Polytropic Head	N m/kg	184,379
Polytropic Efficiency	%	72.30

State Point Results	Units	Inlet	Discharge
Specific Volume	m³/kg	0.067	0.061
Pressure	kPa a	14,450	17,340
Temperature	°C	60.00	84.40
Enthalpy	kJ/kg	2,742	2,997
Entropy	kJ/kg °K	16.44	16.64
Saturation Temperature	°C	-229.5	-229.5
Specific Heat (Cp)	kJ/kmol °K	10.05	10.11
Compressibility		1.082	1.095
Dynamic Viscosity	mPa sec	0.010	0.011
Sonic Velocity	m/sec	1,216	1,273
K (Cp/Cv)		1.366	1.363
K (Temperature)		1.384	1.380
K (Volume)		1.524	1.538
Volume Flow	m³/hr	579.0	524.0

Flexware ® Turbomachinery Engineers
Analysis via Gas Flex ®, a BWR gas properties program

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Figure #7. Calculation results for a field test point showing gas details, head, power and efficiency.

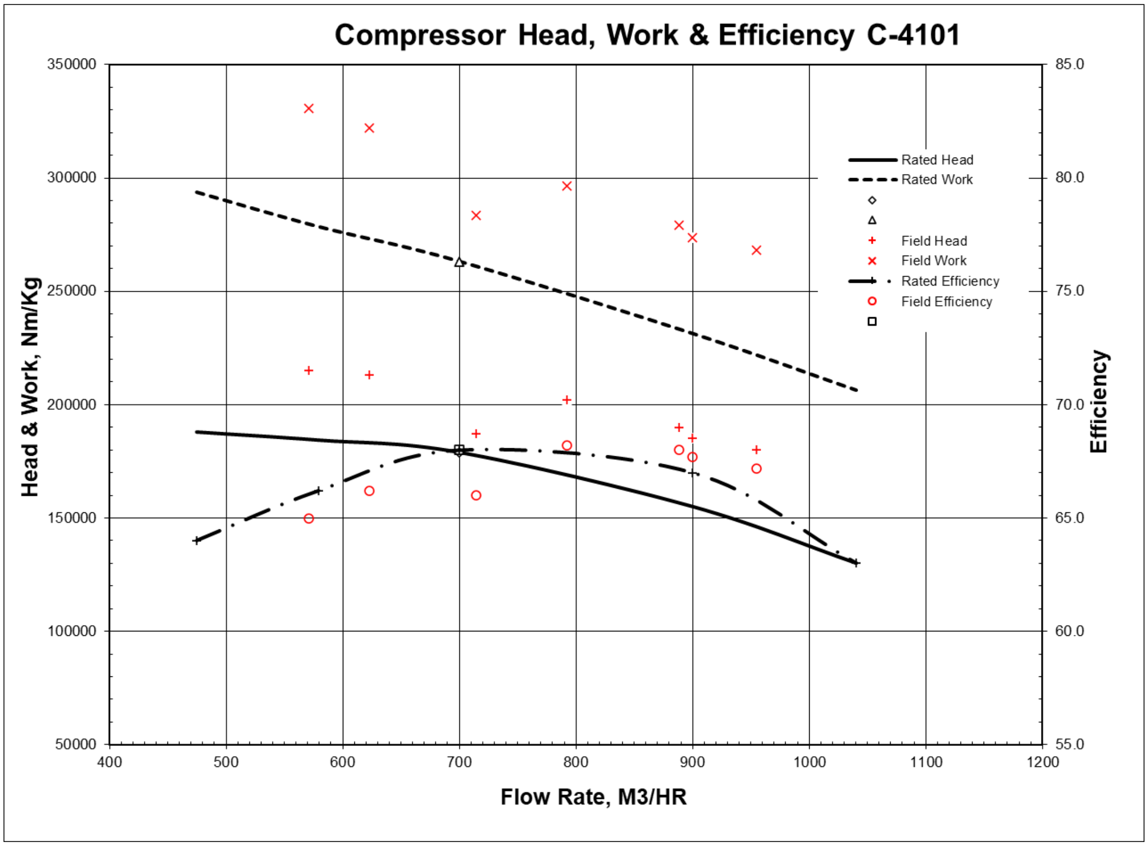

Figure #8. Several test points plotted on the OEM performance curve. After entering the data points for the curve, you may need to make some minor adjustments to the values. Note that the work curve should be a nearly straight line that drops off to the right (higher flow). The head and efficiency curves should be smooth. The efficiency points look good, near the OEM curve, however the head and work are high. Work is always a good indicator of accuracy of the input data. Actual head is never higher than the predicted. As efficiency degrades, the operating value for head will drop below the curve. In this case, while the error could be a bad temperature or pressure probe, the most likely issue is an incorrect gas analysis. At a MW of 3.089, the smallest error in the value of any of the heavies could throw the gas analysis off enough to cause this calculation error.

Ted Gresh
23-Jan-23