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Tech talk #3: "Hose illusions"

Whether caused by wear and tear or damage, each diver amongst us most likely can relate to an occasion where it has been necessary to replace a regulator hose. Changing a hose is no big deal we all can agree upon. However shall we replace the hose with an original manufacturer's one or just use a generic one at the fraction of the price is the question? As you might already guess, the answer isn't that simple...

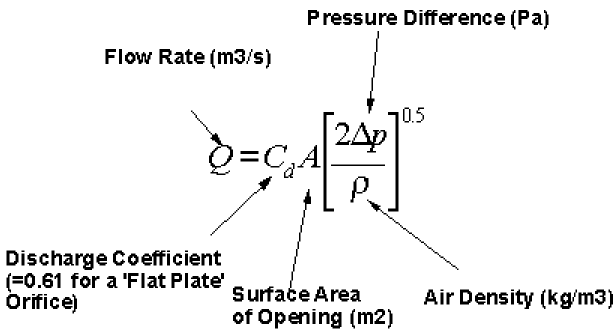
A key-point to keep in the back of your mind is that manufacturers design their regulators to supply a certain volume of air at a given depth and maximum demand conditions. For regulators to pass EN250, simplified, this respiratory minute volume is 62.5 l/min at the surface, a test depth of 50m and a supply pressure of 50 bar.

In order to solve this riddle, we'll have to look into air flow. Primarily the amount of air flow through a hose is directly related to the diameter of the hose (and its restrictions, e.g. the fittings) and the air pressure supplied through the hose. A smaller diameter or lower pressure will result in a lower air flow through the hose. Secondary factors that will limit that flow include but are not limited to the length of the hose, tight bends, hose imperfections, material selection... All those factors create turbulence in the air flow, increase the drag and thus increasing overall frictional losses in the hose.

Finally as a diver we should understand that as the depth increases, not only our relative air demand increases, but so does the air density. Hence, at depth, those frictional losses will increase even more.

All those losses under dynamic or flow conditions (i.e. a breathing diver) can result in a reduced pressure at the second stage end compared to the first stage. As mentioned before, a reduced pressure will reduce the airflow even more.

For the mathematically inclined under us, the flow through an orifice can be captured in the below formula. Disregarding the discharge coefficient, this formula shows the relationship between the diameter of the orifice (surface area), pressure difference and the air density.



$$Q = C_d A \left[\frac{2\Delta p}{\rho} \right]^{0.5}$$

A lot of talk to absorb, so let's try to visualize this. I took some regulators and hooked them up to the flow bench in order to simulate air flow scenarios at the surface (atmospheric pressure) through original and generic hoses at different supply pressures. The goal is to establish the maximum achievable air flow through different hoses. Where applicable I did not connect the second stage hose up to the preferred port as not to bring another factor into play. Finally our test were restricted to a supply pressure of 1000 psi / 69 bar as most of the dynamic variations will occur in this lower supply pressure range. Increasing the supply pressure above 1000 psi did not result in any higher flow rates in any of the test. Note again that the test was performed at atmospheric pressure and therefore the results should not be extrapolated to predict the performance at depth; I'm convinced that there is a correlation between atmospheric and depth test results however no study is available to establish this relationship.

- Scenario 1: Scubapro MK2 first stage with manufacturers hose versus generic hose. Both hoses have a length of 76 cm. The smallest diameter of the original hose is 5.1mm and the smallest diameter of the generic hose is 4.5mm. The maximum flow achieved through the original hose is 38 SCFM / 1076 lpm versus 34 SCFM / 963 lpm for the generic hose. On the graph the original hose performance is plotted in green, the generic hose in red.
- Scenario 2: Mares MR12ST first stage with manufacturers hose versus generic hose. The original hose has a length of 80 cm and the generic hose has a length of 76 cm. The smallest diameter of the original hose is 5.1mm and the smallest diameter of the generic hose is 4.5mm. The maximum flow achieved through the original hose is 50 SCFM / 1416 lpm versus 42 SCFM / 1189 lpm for the generic hose. On the graph the original hose performance is plotted in green, the generic hose in red.
- Scenario 3: Diverite RG3 first stage with manufacturers long hose versus 2 generic long hoses. All hoses have a length of 210 cm. The smallest diameter of the original hose is 4.5mm, the smallest diameter of the generic hose 1 is 4.5mm and the smallest diameter of the generic hose 2 is 4.9mm. The maximum flow achieved through the original hose is 39 SCFM / 1104 lpm versus 39 SCFM / 1104 lpm for the generic hose 1 and 45 SCFM / 1274 lpm

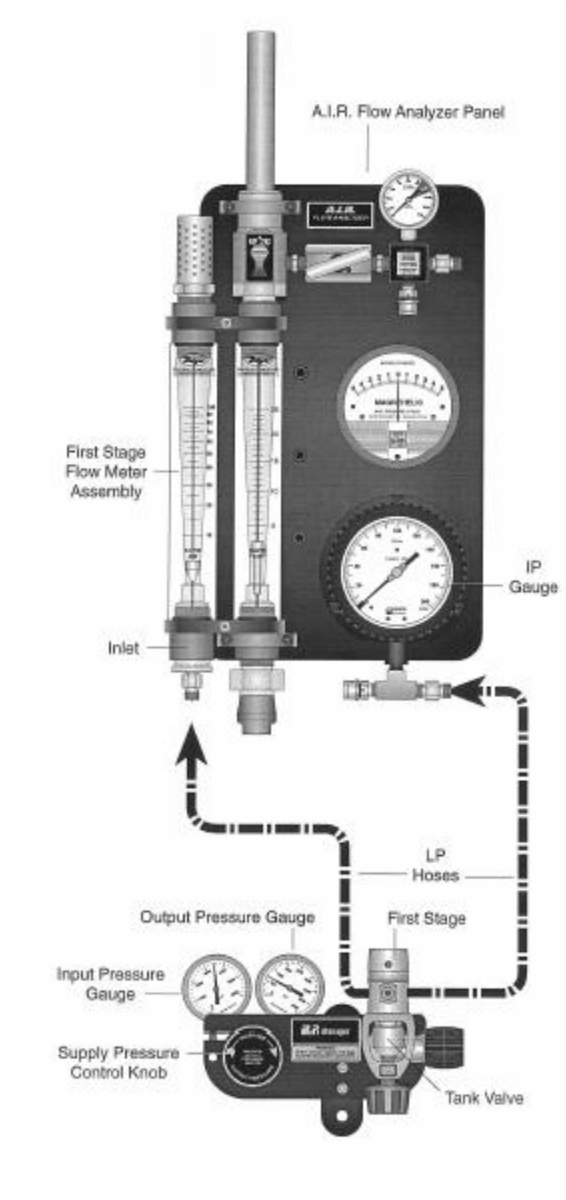
for generic hose 2. On the graph the original hose performance is plotted in green, generic hose 1 in red and generic hose 2 in yellow.

Conclusion: this experiment confirms that firstly smaller diameter hoses will restrict the maximum achievable flow through the hose and hence changes the performance characteristics of your regulator. As well, let's not lose out of sight that that the maximum achievable flow will depend on the regulator/brand.

In doubt or you'd like to know the flow through different hoses before making your purchase decision, consult your professional repair centre; they should be able to flow test the hoses for you.

This article does not favour any brands nor claims performance comparisons between brands or condemns brands, it's just an experiment.

Experiment set-up:



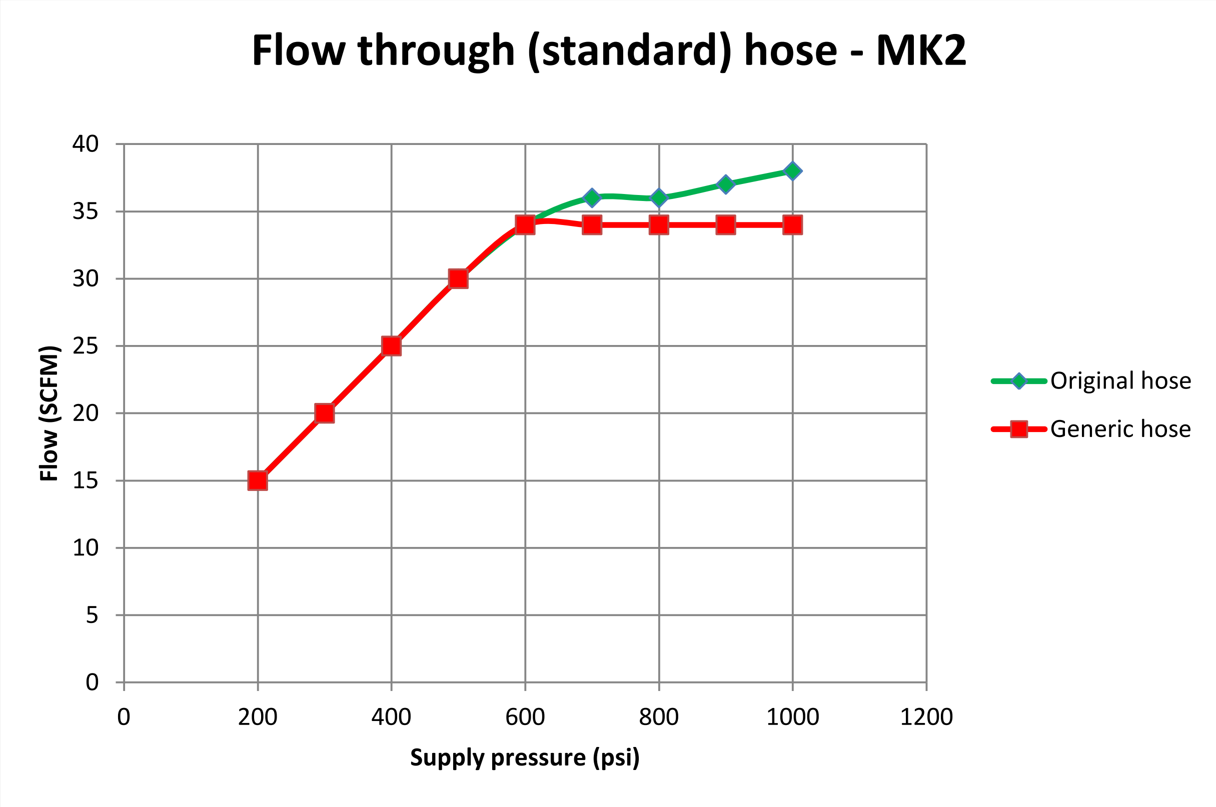
Effect of high flow rates through a regulator: Joule-Thompson effect or freezing of the regulator even in tropical conditions.

Scenario 1:

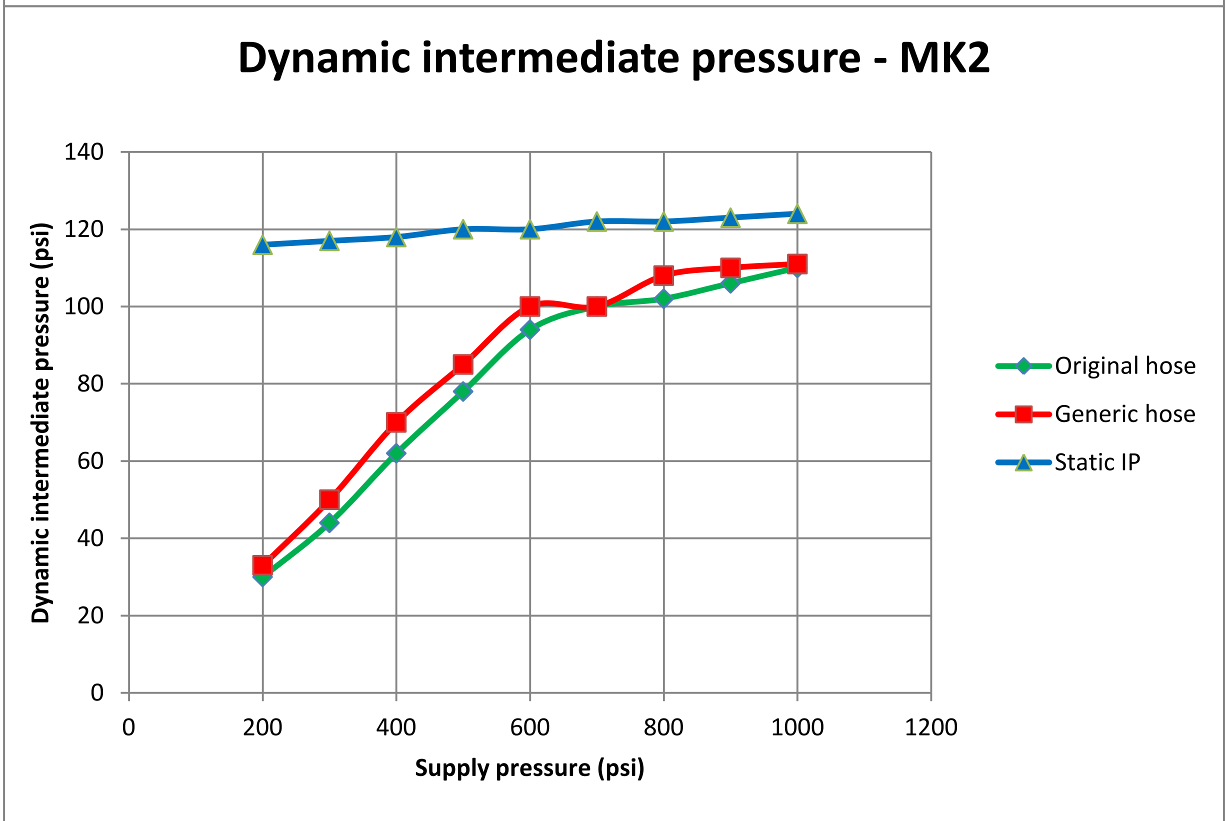
Scubarpo MK2+							
Supply pressure	Original hose				Generic hose		
	Static IP	Dynamic IP	Flow	Flow	Dynamic IP	Flow	Flow
psi	**psi**	**psi**	**lpm**	**SCFM**	**psi**	**lpm**	**SCFM**
200	116	30	425	15	33	425	15
300	117	44	566	20	50	566	20
400	118	62	708	25	70	708	25
500	120	78	850	30	85	850	30
600	120	94	963	34	100	963	34
700	122	100	1020	36	100	963	34
800	122	102	1020	36	108	963	34
900	123	106	1048	37	110	963	34
1000	124	110	1076	38	111	963	34
2000	130						
3000	137						

max flow 38 max flow 34

	Diameter (mm)			Length (cm)	
	original	**generic**		**original**	**generic**
1st stage side	5.1	4.5		76	76
2nd stage side	5.1	4.5			



Flow through (standard) hose - MK2
Flow (SCFM)
40
35
30
25
20
15
10
5
0
0
200
400
600
800
1000
1200
Supply pressure (psi)
Original hose
Generic hose



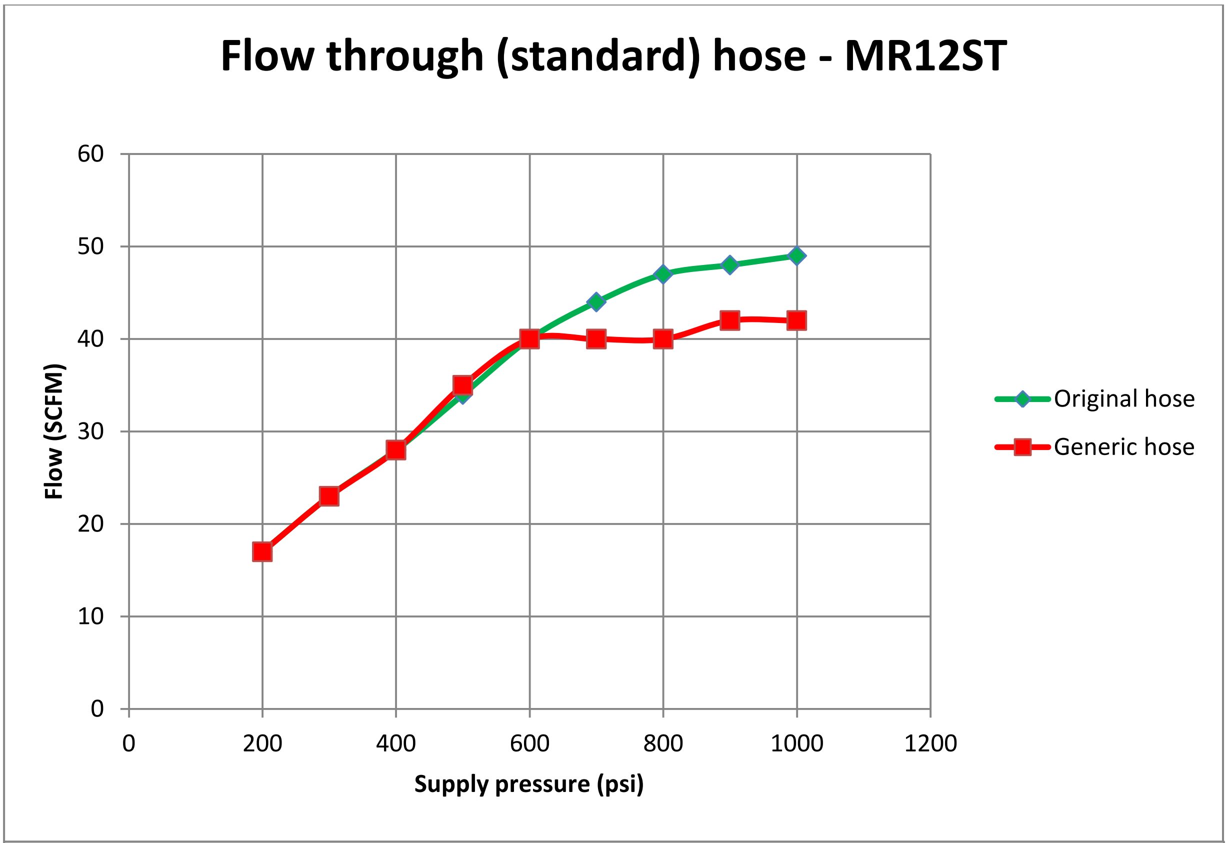
Dynamic intermediate pressure - MK2
Dynamic intermediate pressure (psi)
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
Supply pressure (psi)
Original hose
Generic hose
Static IP

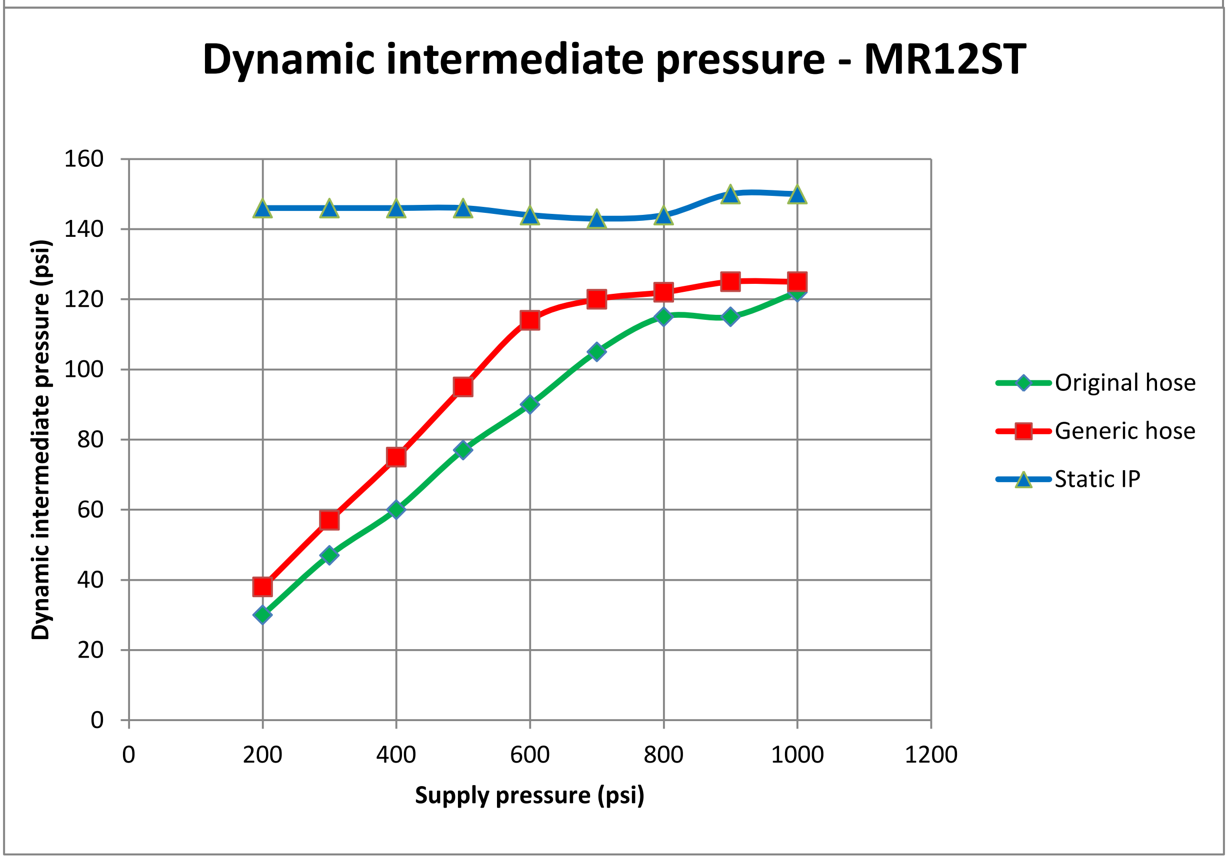
Scenario 2:

Mares MR12ST- non DFC port							
Supply pressure	Original hose				Generic hose		
	Static IP	Dynamic IP	Flow	Flow	Dynamic IP	Flow	Flow
psi	psi	psi	lpm	SCFM	psi	lpm	SCFM
200	146	30	481	17	38	481	17
300	146	47	651	23	57	651	23
400	146	60	793	28	75	793	28
500	146	77	963	34	95	991	35
600	144	90	1133	40	114	1133	40
700	143	105	1246	44	120	1133	40
800	144	115	1331	47	122	1133	40
900	150	115	1359	48	125	1189	42
1000	150	122	1388	49	125	1189	42
2000	148						
3000	147						

max flow 50 max flow 42

	Diameter (mm)			Length (cm)	
	original	generic		original	generic
1st stage side	5.1	4.5		80	76
2nd stage side	5.1	4.5			

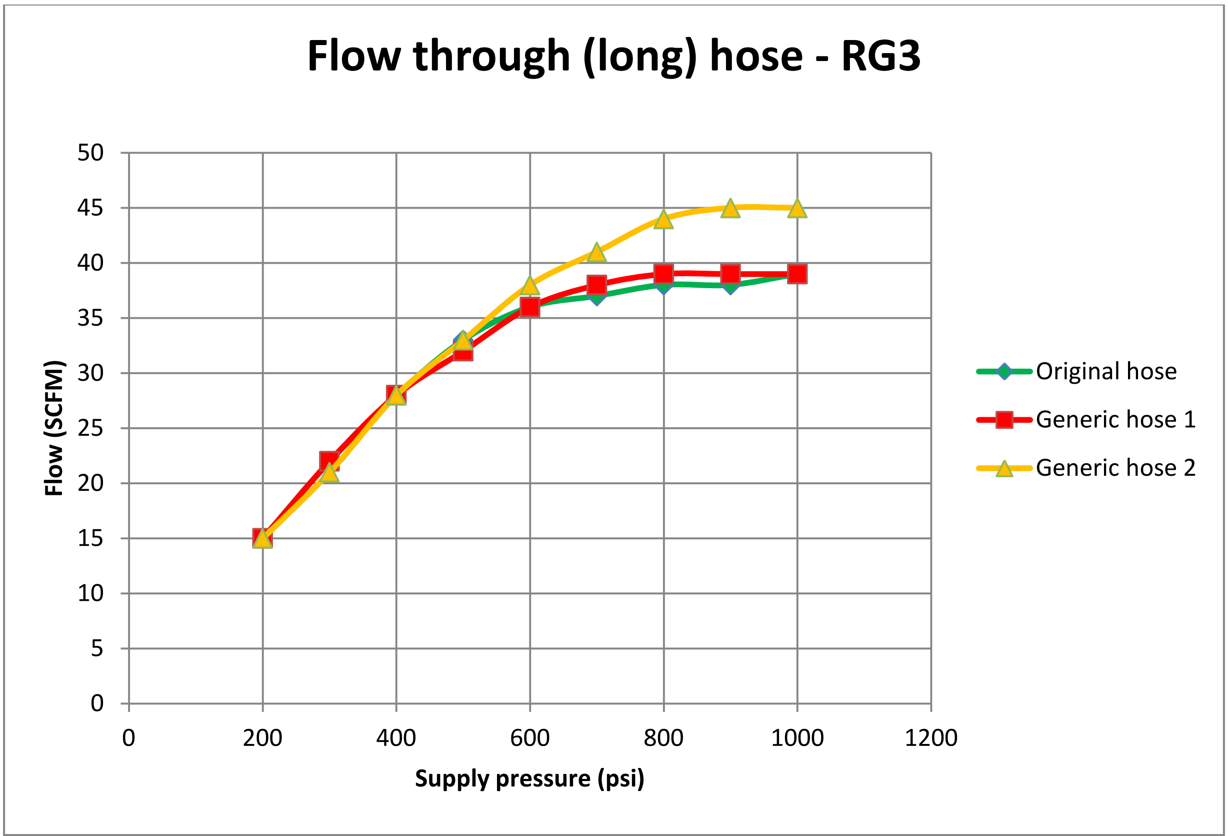

Flow through (standard) hose - MR12ST
Flow (SCFM)
Supply pressure (psi)
0
10
20
30
40
50
60
0
200
400
600
800
1000
1200
Original hose
Generic hose

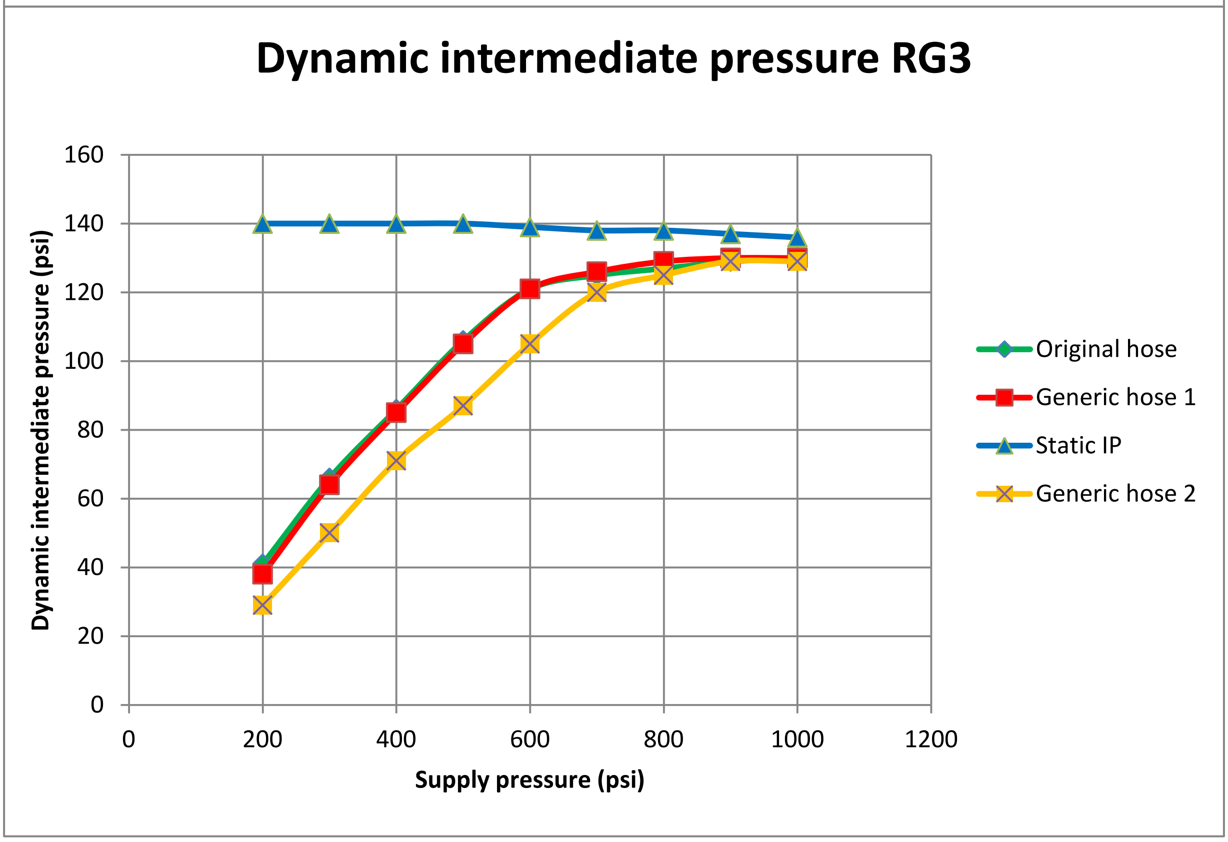

Dynamic intermediate pressure - MR12ST
Dynamic intermediate pressure (psi)
Supply pressure (psi)
0
20
40
60
80
100
120
140
160
0
200
400
600
800
1000
1200
Original hose
Generic hose
Static IP

Scenario 3:

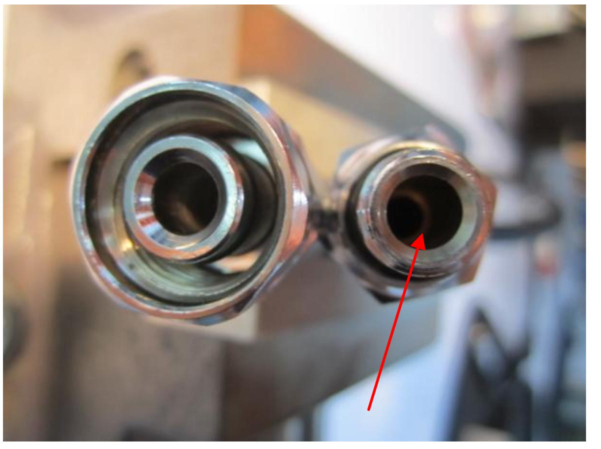
Diverite RG3 with long hose										
Supply pressure	Original hose				Generic hose 1			Generic hose 2		
	Static IP	Dynamic IP	Flow	Flow	Dynamic IP	Flow	Flow	Dynamic IP	Flow	Flow
psi	psi	psi	lpm	SCFM	psi	lpm	SCFM	psi	lpm	SCFM
200	140	41	425	15	38	425	15	29	425	15
300	140	66	623	22	64	623	22	50	595	21
400	140	86	793	28	85	793	28	71	793	28
500	140	106	935	33	105	906	32	87	935	33
600	139	121	1020	36	121	1020	36	105	1076	38
700	138	125	1048	37	126	1076	38	120	1161	41
800	138	127	1076	38	129	1104	39	125	1246	44
900	137	129	1076	38	130	1104	39	129	1274	45
1000	136	130	1104	39	130	1104	39	129	1274	45
2000	133									
3000	130									
			max flow 39			max flow 39			max flow 45	

	Diameter (mm)				Length (cm)		
	original	generic 1	generic 2		original	generic 1	generic 2
1st stage side	4.8	4.5	4.9		210	210	210
2nd stage side	4.5	4.5	5.1				


Flow through (long) hose - RG3
Flow (SCFM)
50
45
40
35
30
25
20
15
10
5
0
0
200
400
600
800
1000
1200
Supply pressure (psi)
Original hose
Generic hose 1
Generic hose 2


Dynamic intermediate pressure RG3
Dynamic intermediate pressure (psi)
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
Supply pressure (psi)
Original hose
Generic hose 1
Static IP
Generic hose 2

Hose comparison:



Original mares hose
Smooth bore no restrictions

Generic hose
Restrictions