Resin infusion – vacuum troubleshooting and handy tips

For those of you who already use resin infusion in your processes, you're more than likely to have come unstuck with a vacuum issue at some point. Whether an undetectable leak or a poor vacuum, the causes of these can be difficult to find and can increase setup time dramatically.

With a little more understanding about vacuum for infusion, you can greatly reduce such occurrences. Vacuum leaks are difficult to detect and this difficulty is usually proportional to the size of your part or component. Ultrasonic equipment may help to find pinhole leaks but the process also requires patience and a bit of luck. More times than not, the infusion carries on and the leak is discovered as the resin flows and air can be visibly seen entering the bag. This always happens in bag leaks.

Getting down to a suitable vacuum level for infusion does not have to be a 'fingers crossed' situation. Here are some tips to ensure you are getting the most out of your vacuum system, hose connections and fittings.

Vacuum System: This is often a highly overlooked piece of equipment. Unlike standard vacuum bagging pumping equipment, careful consideration and advice should be sought to ensure you have a system you can trust that is the most efficient size for the job you will be infusing. A bare pump supplier maybe unaware of your application requirements. For a fuller perspective talk to VABS for information about a suitable vacuum system to suit your manufacturing needs. A bare pump may be a cheap option, but there's much more to vacuum infusion than just the pump. Precise control of the pump is a vital requirement for a successful infusion. Fittings and connections need to be leak tight and tested for their vacuum integrity.

Our Vacmobile systems are purpose designed for infusion. Vacmobiles reduce the risk of vacuum leakage to a very low level. When working with high value composites, the extra reliability of a Vacmobile system may repay its purchase price many times over.

Hose connections: In order to maximise the flow rate you have to match the total port area to the port area of the pump. Example: If your pump has a 1 ¼" inlet connection you can be sure that this is the best port size for this pump output. Piping this connection down to one ½" connection will strangle the flow and reduce overall capacity and increase production time. In this case you will need to provide up to 6 x ½" or 2 x ¾" connections to your bag to minimise de-bulking time of the laminate.

Fittings: For resin infusion, a clear polyethylene hose is recommended, mainly for its properties under vacuum. It can be crimped and sealed easily without collapsing the tube and its transparency allows visual checking of resin flow. Whilst cheaper hoses are available, they will not provide the user with the above benefits. A cheap hose is not a cheap hose if a vacuum system has to be replaced due to resin ingestion.

Bag fittings and resin trap fittings can lead to the downfall of a well-designed vacuum system. Mastic tape should not be used as a substitute for a poor joint or fitting. VABS has developed its own range of mechanical fittings for use with resin traps and vacuum bags. Leak tight reusable mechanical fittings will save time and ensure vacuum integrity is maintained.

The Vacmobile VB 'AL' series – Super heavy duty high capacity systems with a range of control options

The 'Mini 20' – Our most portable integrated resin infusion system available for medium sized component manufacture

VABS range of purpose built resin traps, hose connectors, infusion hose, gauges, and bag fittings.

Vacmobile® Composite Systems

The Vacmobile 'VB' series – High capacity single phase & three phase vacuum bagging systems.

The Vacmobile 'Compact' –Purpose built resin infusion vacuum systems with integral resin trap

The 'Quick-draw' – Revolutionary patented design, capacities up to 120m³/hr **Single Phase!**

Resin infusion continued...

Assuming the optimum vacuum system choice to start with, achieving a level of vacuum suitable for resin infusion is determined by...

- Rate of evacuation
- Lack of leaks
- Use of flow media
- Moisture and out-gassing of materials

As discussed above, rate of evacuation will be dependent on the size of your vacuum system and how successfully you have plumbed it into your bag to utilise the pump output.

Preparation of flow media in a vacuum bag is important for two reasons. Firstly for creating an efficient path for air to escape from the part. It is possible that bag pressures at full vacuum can vary from one end of the bag to the other solely due to trapped air that can't escape. One way to check bag pressures is to install two gauge ports at opposite ends of the bag prior to infusion. Different readings indicate either trapped air or moisture (See next section). Parts with complex geometry require a little more attention as air will get trapped in tight corners or sharp bends. Secondly, careful flow media preparation ensures a resistance free path for the resin to flow into the part.

Moisture is usually the least understood factor when it comes to vacuum. Core material and laminate materials can absorb moisture if improperly stored. Most infusions will take place at less than 20mbar (absolute). If you cannot achieve a vacuum level better than this and a vacuum drop test reveals a minimum leak back rate you can assume moisture is present in the laminate.

At normal atmospheric pressure, water will boil at 100°C. Under vacuum, water boils at a lower temperature. For instance, at a vacuum level of 24 mbar (absolute), the boiling point of water is 20°C.

Given this fact, you can now apply it to your infusion to get an understanding of what's happening inside the bag. If , for example, you had 1 litre of moisture trapped in your core or laminate, that moisture will turn into approximately 10 cubic meters of water vapour.

This expanding gas must be removed by the vacuum system before a better level of vacuum can be achieved, with the removal time being proportional to how much moisture is trapped in the laminate and the maximum capacity of the vacuum system.

To avoid loss of production time from moisture evaporation, raw materials should be stored dry.

Resins and out-gassing: Some resins, particularly Polyesters and Vinyl-esters, will out-gas under vacuum. The level of vacuum for this effect to take place is dependent on the vapor pressure of the solvents present in these resins. Resin suppliers will be able to advise these vapor pressures and the correct level of vacuum to be applied at the end of an infusion to avoid unnecessary out-gassing of the solvents required for the curing process.

De-gassing of resins prior to infusion: Air may be trapped during resin mixing. For high quality results, vacuum degassing of the resin may be required.

Vacmobile® Composite Systems

Boiling temperature/pressure for water

As explained in our resin infusion article, water evaporation under vacuum may limit the vacuum achieved in resin infusion. Moisture in core or laminate materials may also increase production time and cause bubbles to form in the laminate. The table on the right shows the relationship between vacuum & temperature when moisture is present.

This simple table will help you determine if water boil off is limiting the achievable vacuum and extending the process time. This effect will slow down the de-bulking dramatically.

Temperature (°C)	mbar abs
50	123.31
45	95.81
40	73.74
35	56.21
30	42.42
25	31.66
20	23.37
15	17.05
10	12.27
5	8.721
0	6.103

Typical NZ ambient temperature

Ambient Temperature in Vietnam as described by Stompcraft (below). Water evaporation effect noticed at 95 mbar absolute

Volume of 1 kg of water vapour v. pressure. (At temperature of 20°C)

Pressure mbar (absolute)	1000	500	100	10	1	0.1	0.01	0.001
Volume m^3	2.0	2.5	20	200	2000	20,000	200,000	LOTS!

The purpose of this table is to show that very large volumes of vapour are generated when relatively small amounts of water are subjected to increasing vacuum levels.

Vacmobile® proving its worth in Vietnam

VABS was pleased to help out Steve Thompson get his new boatbuilding operation off the ground in Vietnam. Stompcraft now have its first production orders underway. The reliability and ease of use of the Vacmobile systems helped Stompcraft introduce resin infusion methods to a workplace previously used to traditional wooden boat building methods. Stompcraft have two Vacmobile units currently in operation and a third is due to be flown up from New Zealand in the next few weeks.

"The VABS equipment is state of the art, and gives us fantastic results every time. The back up and service from the VABS team has been superb"
- Steve Thompson

Pictured L-R: Steve Thompson, Lawson Dixon, Philip Elliot
At the new factory in Vietnam with their Vacmobile system

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'Gauge' and 'absolute' pressure made easy

Gauge vacuum				Condition	Absolute pressure	
- psi	-kPa	" Hg	% vacuum		Torr	mbar
0	0	0	0	Standard atmosphere	760	1013
-3.8	-25.3	7.5	25%		570	759.8
-7.4	-50.7	15.0	50%		380	506.5
-11.0	-77.0	22.4	75%		190	253.3
-13.2	-91.2	26.9	90%		76	101.3
-14.7	-101.3	29.9	100%	Absolute zero of pressure	0	0

Vacuum gauges referenced to atmospheric pressure – typically the common Bourdon tube analogue gauge - are not suitable for the measurement of high vacuum because atmospheric pressure wanders around with the weather and with altitude. Atmospheric pressure can easily vary by +/- 15 mbar (and much more in severe storm conditions and at high altitudes)

Vacuum applications such as resin infusion call for peak vacuum levels ranging from 1 mbar (abs) to 20 mbar (abs). For accurate measurement of absolute pressures less than 20 mbar (abs) it is necessary to use gauges referenced to the absolute zero of pressure. While there are several types they are generally known as absolute pressure gauges. VABS has a range of easy to use digital absolute vacuum gauges suitable for use in resin infusion applications.

Call VABS for a demonstration at your site.

A typical absolute pressure gauge

VABS Limited, 8 Titan Place, Silverdale, Auckland, New Zealand
Tel + 64 9 426 6110
Freephone 0800 822 726
Email enquiry@vabs.co.nz
Website www.vabs.co.nz
Contacts Derek, Brendan, Cliff

Marine Industry Association NEW ZEALAND