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GROWNOTES

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 11
Pumps, plumbing and components
How they can work together

Graham Betts and Bill Gordon

Key points

- **The correct plumbing will allow all of the components in the spray system to operate as they are intended**
- **Careful consideration must be given to the selection of the pump, plumbing, valves and other components so they match all of the spray applications the operator plans to make**
- **Before the purchase or installation of new components, the operator should consider what the range of flow rates through each component will need to be**
- **The operator should consider how he/she will access, maintain and calibrate all of the components on the sprayer before they are installed**
- **It is important to consider how various components of the spray system, such as the main tank, can be isolated from the rest of the spray system to provide safe access for maintenance and inspections**

Acronyms used in this module

DIN = Deutsches Institut für Normung (DIN), the organisation for German national standards

ID = inside dimension

ISO = International Organization for Standardization

OD = outside dimension

PTO = power take-off

RHS = rectangular hollow section

RPM = revolutions per minute

1. Introduction

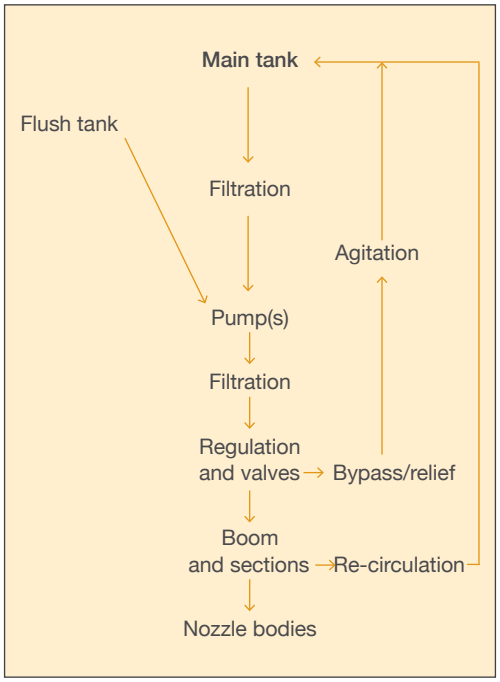
For spraying, the principle of using a pump to transfer liquid from the spray tank to the nozzles remains the same as it has for decades, but the options available to control the flow to the boom and the output from the nozzles has advanced enormously in recent years.

Plumbing has become increasingly important as spray application equipment has increased in size and complexity. There are many options available, so the operator must ensure that the plumbing and components chosen are suitable for the task and correctly installed to allow the sprayer to perform as intended.

There are entire books written about sprayer pumps and components so the aim of this module is not to 'reinvent the wheel', but to provide information and tips on how the components can best work together, along with how to best install them into the spraying system to ensure it continues to operate efficiently and effectively.

The major components of the spraying system and considerations discussed in this module are outlined in Figure 1.

Figure 1 Overview of the major components of the plumbing system.



Things for the operator to consider

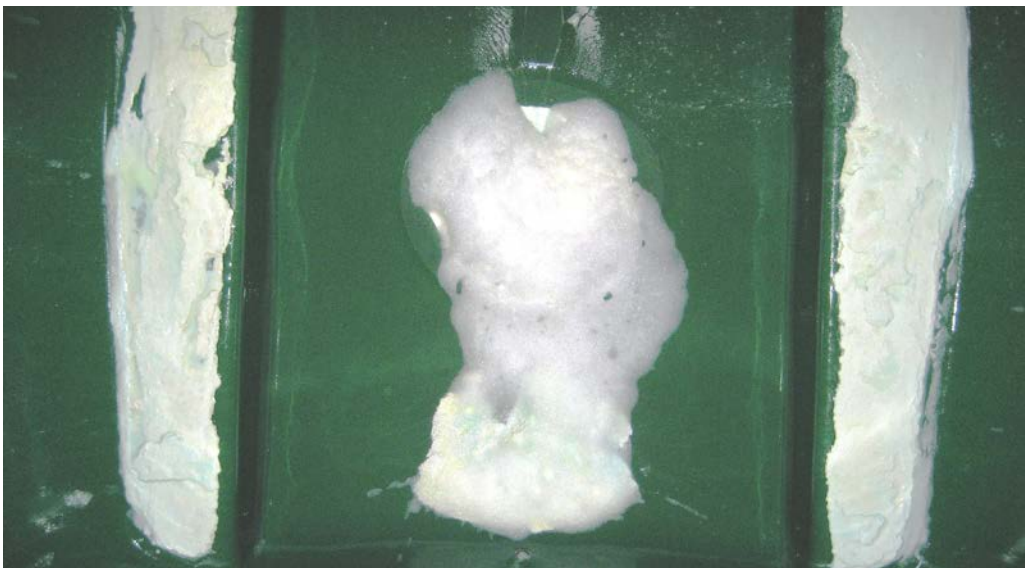
Main tank: shape, sumps, isolation
Flush tank: size relative to main tank
Filtration: suction, pressure, section, nozzles
Pumps: diaphragm, centrifugal
Regulation: pressure relief, bypass,
Agitation: sparge, venturi
Valves: two way, three way
Re-circulation: manual or electric
Nozzle bodies: wet boom, dry boom,

2. The main spray tank

The most common materials that spray tanks are manufactured from are stainless steel, polypropylene and fibreglass (with a shiny layer of glass on the inside, no fibre showing). Of the three, stainless steel tanks will increase the sprayer's weight, but will also tend to hold their shape (and known volume) better than the other materials.

The most important requirements of the main spray tank are that there are no internal ledges and that it is shaped so it is relatively easy to keep products agitated and in solution. The main tank should also have a tapered bottom with a main and secondary sump.

Residue on tank ledges



Product can become trapped unless it can circulate freely in the tank.

Photo: Graham Betts

2.1 Main sump and secondary sump

The main sump needs to be in the lowest point of the tank, and positioned so that the sprayer frame does not prevent the installation of a tank outlet at the bottom of the sump (not at the side of the sump).

The secondary sump is the shape of the tank floor, which should taper from all corners and edges of the tank into the main sump. There should only be one hole at the base of the tank (sump) for the outlet. An additional hole should only be installed at the end of an elongated tank if Venturi agitation is to be fitted.

All other plumbing and return hoses to the tank, including the plumbing for sparge agitators, should be installed into the top of the tank. This will help to reduce potential problems if fittings start to leak and will allow the tank to be isolated from other components. This is particularly important if you need to complete work on the plumbing while the tank is full of water or product, and to help with troubleshooting or cleaning filter screens.

A tank outlet that does not move when installing fittings and allows the tank to totally drain is very practical, e.g. a Banjo® Bottom Drain manifold bolted tank fitting. It is very important to have an anti-vortex fitting in any tank outlet to reduce the chance of the pump sucking air.

TIPS

- **It is important to use a bottom drain tank outlet e.g. Banjo® Poly Bolted Bottom Drain. Tank flanges will allow the tank to be drained completely.**
- **Install an anti-vortex fitting in the top of the tank outlet to help reduce the chance of the pump sucking air when the tank is low.**
- **Install a manual ball valve on the tank outlet so the main spray tank can be isolated if there is a problem with the sprayer.**
- **It is ideal to use ‘flange’ or ‘fly-nut-and-tail’ fittings to make installation, adjustment, maintenance, servicing and repairs easier. For example, removing a centrifugal pump to be repaired would be very easy if the pump inlet and outlet fittings are flange or nut-and-tail fittings. Ideally these fittings could be used at any location on the sprayer on components that may need to be serviced, adjusted or replaced.**

3. The flush tank

The flush tank should have a capacity that is at least 10 per cent of the capacity of the main tank.

It is ideal if the flush tank has its own fill hose from the fresh-water source to reduce the chance of contamination, along with a 'one-way' or 'check' valve in the suction line so mixed product cannot move from the main spray tank into the flush tank.

Flush tanks are very important for being able to easily flush the pump, spray components and nozzles in the field, especially if the main spray tank has not been emptied.

4. Hand-wash tank

The hand-wash tank (clean water) must be independently plumbed so there is no way it can become contaminated. It should have a dedicated fresh water supply fitting that is different to any of the other liquid connections on the sprayer.

Carefully consider the volume of water this tank will hold, many safety data sheets state that eyes must be flushed with running water for 10 to 15 minutes if product accidently splashes into them. It is also ideal to have a soap dispenser next to the hand wash container.

5. Filtration

Filtration is critical for protecting the sprayer's components and to reduce the potential for nozzle blockages. Generally, filters are placed before the pump (suction), after the pump (pressure) and before the nozzles (often on boom sections).

There is an ISO standard for the colour of filter screens (related to their mesh size), but unfortunately not all manufacturers use this ISO colour code. When ordering a filter it is itherefore mportant to state the mesh size required for the screen, not just the colour.

Example of filter screen

Different brands of filter screens are not always the same colour for the same mesh size.

Source: TeeJet®

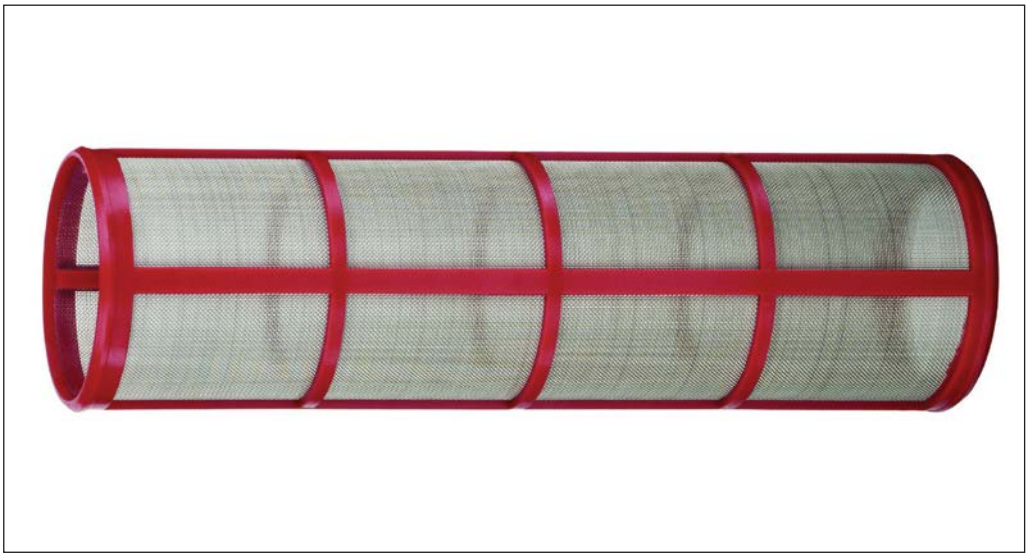


Table 1 The ISO colour code for filter mesh sizes.

ISO colour code	Brown red	Red	Blue	Yellow	Green	Grey (non-ISO)	Orange	Pink
Mesh size	16	32	50	80	100	120	150	200

TIP

- **Ideally, filters should be located where they are easy to access. Locate filter bowls facing downwards, and have a manual ball valve on the bowl so the filter is easier to service.**

5.1 Suction filters

The suction filter is located between the tank outlet and the pump.

Suction filters for centrifugal pumps, should ideally have a 16-mesh screen or similar, which is the most appropriate filter screen size to reduce the chance of any foreign material getting caught in the pump's impeller.

Suction filters for diaphragm pumps, should ideally have a 30 or 50-mesh screen, which are the most appropriate filter screen sizes to protect positive-displacement pumps.

5.2 Pressure filters

Ideally, the main pressure filter will be installed after the pump but before any of the plumbing components (such as the flow meter and regulating valves).

The main pressure filter should have either 80 or 100-mesh screens, which are suitable for both centrifugal and diaphragm pumps. It is important to have a pressure-relief valve installed between the pump and main pressure filter when using diaphragm pumps.

5.3 Boom-line filters

Boom-line filters should also have 80 or 100-mesh screens. However, the mesh size can be changed to suit the nozzle orifice size or formulation type according to the recommendations on the product label.

It is best to mount the boom-line filters out on the boom sections. They should be plumbed into the spray line at a point as close as practical to where the spray line connects to the boom line.

5.4 Nozzle filters

The mesh size for nozzle filter screens, where fitted, should match the nozzle orifice size. Most nozzle manufacturers will recommend filter sizes to match particular nozzles.

Nozzle filters

Installing boom section filters may be more useful than using nozzle filters.

Photo: TeeJet®

For most situations, it may be preferable that nozzle filters are not installed. Generally if there is a problem with products blocking nozzles, the source of the problem will be filtration upstream from the nozzles.

Nozzle filters can accumulate material on the filter screen due to the low liquid flow rates that occur through a single nozzle. At low flow rates the filter screen can strip components out of the formulation (detectable as a film on the screen).
This generally does not occur when the same mesh-size screen is used on the boom filters due to the higher flow rates of liquid that will flow to a whole boom section compared to a single nozzle.

From the operator's perspective, it may be better to have a blocked nozzle that can be easily seen, rather than a nozzle that has restricted the flow due to a partially blocked nozzle filter.

TeeJet® filter bowl with thread at base

Threaded filter bowls allow a ball valve to be installed for flushing the filter.

Teejet® image library

TIPS

- The main reasons for having a suction filter on a centrifugal pump are: to protect the pump by taking coarse foreign matter out of the spray solution; and to reduce the amount of work the main pressure filter has to do.
- You may need to match the mesh size of the pressure filter screen to the product being used, according to information on the product label, or to the nozzle orifice size.
- All filters should be mounted so the filter bowl is facing down. This way any foreign material falls out when the bowl is removed. It is practical to have a manual ball valve at the base of the filter bowl so the filter can be flushed clean without the bowl having to be removed.
- Have a full set of gaskets or O-rings on hand. Operators can waste a lot of time trying to install filter bowls with swollen gaskets or O-rings. It is useful to place swollen O-rings and gaskets in direct sunlight for several hours (or days) to see if they shrink back to their normal size

6. Pumps

PLAY VIDEO

Determining pump capacity – diaphragm pump example

The most common types of pumps used on sprayers are diaphragm pumps (positive displacement), centrifugal pumps (non-positive displacement) and, to a lesser extent, roller pumps.

Before selecting a pump for the sprayer, the operator needs to know what the expected range of flow rates and operating pressures are likely to be. After establishing this, the operator should carefully examine each pump's performance curve (which shows the pump's flow rate at different pressures) to see which model suits their requirements.

Evaluating the performance curve is particularly important when considering purchasing a centrifugal pump or a 12-volt diaphragm pump.

The main factors to look at when choosing between diaphragm and centrifugal pumps are the operating pressure required by the nozzles you have chosen to use, and the total volume required (e.g. for the boom and for agitation).

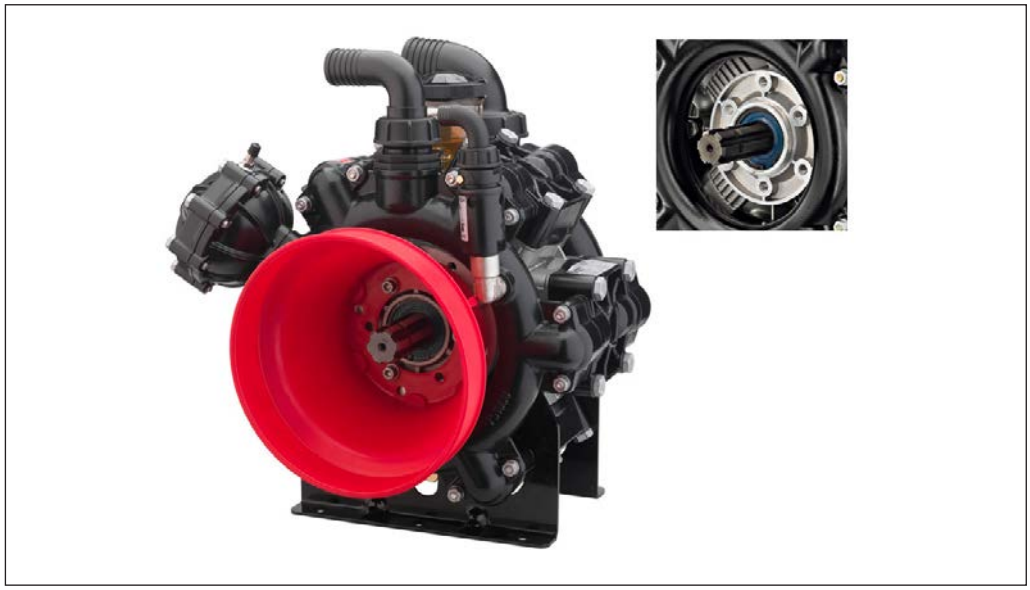
For more information on how different pump types work, go to: sprayers101.com/pumps-for-applying-crop-protection-products/

6.1 Diaphragm pumps

Diaphragm pumps are good for maintaining the flow rate (litres per minute) across the entire pressure range the pump is rated for. For example, the same diaphragm pump can deliver 170L/min at 2.0 bar pressure and 165L/min at 15.0 bar pressure.

Diaphragm pumps are designed to operate at either 540 RPM or 1000 RPM, depending on the make and model of the pump, and may be PTO-driven or hydraulically driven.

Ar150 diaphragm pump



Diaphragm pumps can maintain pressure over their range of flow.

Photo: TeeJet®

There will be an impact of the RPM on pump performance and output. For example, the same diaphragm pump at 450 RPM will produce 135L/min, at 500 RPM will produce 150L/min and at 550 RPM will produce 165L/min.

If using a PTO to drive the diaphragm pump, it is important that the draw bar pin is as close as possible to the halfway point between the two yolks. If this is not practical, you may need to use a wide-angle shaft, with the wide-angle-yolk end most commonly fitted to the tractor. Alternatively, a double bearing block can be installed on the chassis of the sprayer pull.

If using a hydraulic drive system for a diaphragm pump, it is important to have an aluminium block on the hydraulic motor that will not allow the pump to be run at more than 540 RPM. The hydraulic return line for the drive system, which should be ¾", must go back to the 'return' on the tractor hydraulic couplings, not the 'remotes'.

TIP
- **540 RPM diaphragm pumps need to run at a minimum of 450 RPM and a maximum of 540 RPM.**

6.1.1 Diaphragm pumps require a pressure-relief valve

It is essential to install a pressure-relief valve between the pressure outlet of the diaphragm pump and before any other spray components (including the pressure filter). A diaphragm pump must never be dead-headed.

TeeJet® 8460 pressure relief valve

Diaphragm pumps must be fitted with pressure relief valves.

Photo: TeeJet®

The bypass from the pressure-relief valve must be returned back to the main spray tank unrestricted (preferably to the top of the tank). The bypass from the pressure-relief valve, and bypass from the regulating valve can both be connected into a common return line to the main spray tank.

The bypass from a pressure-relief valve should never be connected to an agitator.

TIPS

- Always match the pressure rating of the pressure-relief valve to the pump's maximum operating pressure. For example, if the spray pump has a maximum pressure of 8.0 bar, it would not be a good idea to install a 10.0 bar pressure-relief valve. If the pump was not performing correctly, it may be tempting to screw the pressure relief T-handle in, which may dead-head the pump.
- If you have a TeeJet 8460 model pressure-relief valve it is a good idea to remove the stainless-steel washer from inside the pressure-relief valve to help reduce the pressure spike. Remove the four Phillip's head screws, remove the plunger and diaphragm, undo the Phillip's head screw from the plunger, remove the flat washer and reassemble the pressure-relief valve.

6.2 Centrifugal pumps

Centrifugal pumps are good at delivering larger volumes of flow, generally at lower operating pressures (ideally at pressures less than 5.0 to 6.0 bar).

Centrifugal pumps are good for delivering high volumes of flow.

A Hypro® centrifugal pump

The performance of a centrifugal pump is highly dependent on the hydraulic oil flow to the pump's motor.

For example, for a particular brand of centrifugal pump and hydraulic motor combination:

- at an oil flow of 56.8L/min, the total output is 830L/min at 2.8 bar and 72L/min @ 7.6 bar;
- at an oil flow of 60.6L/min, the total output is 830L/min at 2.8 bar and 159L/min. at 8.3 bar; and
- at an oil flow of 64.4L/min, the total output is 830L/min at 2.8 bar and 220L/min. at 9.0 bar.

Match the hydraulic motor to the tractor's hydraulic system capacity

There are commonly five different models of hydraulic motors fitted to centrifugal pumps. It is important to match the hydraulic motor for the centrifugal pump to the actual tractor model and its hydraulic system capacity.

Always refer to the manufacturer's technical literature for an appropriate pump model to match the hydraulic oil flow available on the tractor or sprayer.

Centrifugal pump with vent hose

Always install a vent line on centrifugal pumps according to the manufacturer's instructions.

Photo: Graham Betts

TIPS

- When using hydraulic-drive centrifugal pumps it is important to read the instructions, particularly the one requiring the installation of a vent line.
- Use ¾" hydraulic hose for the hydraulic return line from the hydraulic motor, which must be returned to the dedicated 'return' fitting in the tractor, not 'remotes'.
- When connecting all hydraulics for pumps, connect the return line first and then the pressure line. When disconnecting, remove the pressure line first and the return line last.
- The flow from the outlet of the pump should go to the nozzles with the least number of fittings and bends in the hose. Make sure that any fittings used are the same size or larger than the outlet size on the pump.
- It is not practical to service spray components if they are solid-mounted on the pump

6.3 Agitation systems

The agitation in the main spray tank must be able to agitate product that may have settled to the bottom of the tank when the pump has been turned off, or where the products were not correctly mixed. This is particularly important when using powdered or granular formulations.

There are two main types of agitation system: Venturi and sparge.

Venturi agitators are normally used with diaphragm pumps (at high pressure) and sparge agitators are mainly used with centrifugal pumps (at high volume).

Venturi agitators in a John Deere sprayer

Venturi agitators typically require higher pressures to engage and operate effectively.

Photo: Graham Betts

Venturi agitators require both pressure and flow to perform correctly. Most manufacturers of Venturi agitation systems only provide performance information for operating pressures above 5.0 bar.

Sparge agitation systems are relatively simple, comprising a tube running the length of the tank with a series of holes in either side of it to direct liquid downwards and to the sides of the tank. The sparge tube is normally placed quite low in the tank to ensure the liquid flow is able to move product that may have settled. However, to be able to do this a high volume of liquid must flow through the sparge tube.

Sparge agitation tube in the base of a Rogator® tank

Ideally, sparg® agitator tubes would be fed from the top of the tank.

Photo: Graham Betts

TIPS

- It is ideal to have a dedicated agitation pump, especially with the larger main spray tanks that many modern sprayers have.
- If you are using the spray pump for product transfer and spraying it is important to have two separate pressure-regulation systems. One system for spraying and agitation, e.g. a pressure-relief valve set at 6.0 bar, and the second system set at 10.0 bar for transfer. If using only one regulation system (for boom, agitation and filling) which has been set to around 10.0 bar for transfer, the performance of the sprayer could be compromised because the regulating valve could be in the wrong position, which will greatly affect the sprayer's ability to adjust the application rate in response to changes in speed or section control.

6.4 Determining required pump capacity (for boom flow and agitation)

To determine the pump and plumbing capacity required for the sprayer, the operator must consider the range of flow rates that are likely to be required by the boom, as well as the additional capacity required to run the agitation system efficiently.

Working out the pump capacity required for a sprayer

Hypro Pumps recommends that:

"The flow required from the pump should be the total of the flow required for the boom, plus the flow required for agitation, plus another 20% for a buffer."

As a guide, agitation requirements for different products in the tank mix are as follows:

- for liquid products, the agitation requirement is the tank volume x 0.05 in litres per minute; and
- for powders or 'flowables' the agitation requirement is tank volume x 0.125 in litres per minute.

(Source: Hypro Pumps, Spray Tips and Accessories Catalogue, 2012.)

It may be useful to complete the following exercise to determine the required pump capacity, and to also consider the pressures required to operate the nozzles and agitation system effectively.

The following example considers the flow rates required to match the boom width and application rates (L/ha) at a range of spraying speeds.

Tip: If section widths are not even, work out the proportion of flow to each section to determine the most appropriate capacity for valves, components and fittings.

Example: Flow requirements for a 24m sprayer, with a 4000L tank, plumbed in seven sections (of equal length) at three common application volumes and three spraying speeds.

Table 2 Calculations of total flow through the boom required for the above example.

Boom width	X	L/ha	x	km/h	÷	600	=	Total litres per minute
24.5	X	50	x	10	÷	600	=	20.4
24.5	X	50	x	20	÷	600	=	40.8
24.5	X	50	x	25	÷	600	=	51.0
24.5	X	75	x	10	÷	600	=	30.6
24.5	X	75	x	20	÷	600	=	61.2
24.5	X	75	x	25	÷	600	=	76.6
24.5	X	100	x	10	÷	600	=	40.8
24.5	X	100	x	20	÷	600	=	81.6
24.5	X	100	x	25	÷	600	=	102.1

Using the above calculations, the operator can determine that for this example he/she will require a pump and plumbing system that can handle flow rates down to 20.4L/min for the main hoses and fittings, and flow rates down to 2.9L/min for the boom section components and fittings (20.4L/min ÷ 7 sections).

From the same example, the operator can also determine that he/she will require a pump and plumbing system that can handle flow rates up to 102.1L/min for the main hoses and fittings, and flow rates up to 14.6L/min for each of the boom section components and fittings (102.1L/min ÷ 7 boom sections).

Agitation requirements

From the previous example, using a 4000L main spray tank, the spray pump needs to be able to deliver:

- 102L/min to the nozzles, at the optimum pressure that the nozzles need to be operated at;
- 200L/min for agitation of liquid formulations (tank volume x 0.05 = agitation volume (L/min)); and
- 500L/min for agitation of powdered formulations (tank volume x 0.125 = agitation volume (L/min)).

From the above example, the total flow required from the pump, when applying liquids at 100L/ha and 25km/h is 102L/min (for the boom) + 200L/min (for agitation) + 20% (buffer) = 362.4L/min capacity (at the required operating pressure).

It may be possible to use a Venturi agitator to achieve the above requirements, but it would be important to check the pressure or flow requirements and ratings for the particular brand of Venturi agitator you may be considering, as some models require a minimum of 5.0 bar pressure to start the agitator.

7. Regulating valves

The purpose of regulating valves is to ensure the required volume of liquid is delivered to the boom or boom sections in response to changes in spraying speed or section control operating. To do this, the liquid flow must either be restricted (throttle mode) or diverted back to the tank (bypass mode).

TeeJet® regulating valve

Regulating valves can work more efficiently when used in conjunction with three way boom valves. ▶

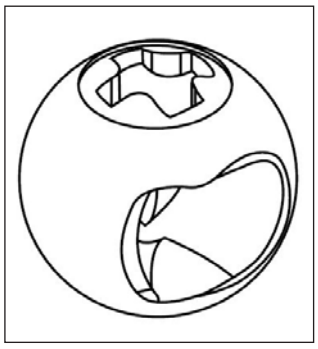
Photo: TeeJet®

Operators should be aware that each sprayer manufacturer may use several different types of regulating valves on their particular brand of sprayer, which they may change between models or over time.

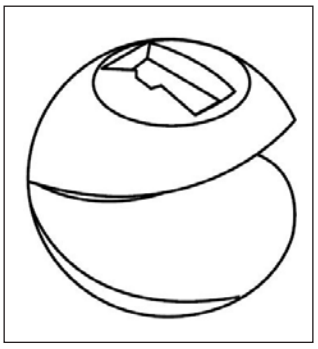
Common types of regulating valves include ball valves, plunger valves and butterfly valves.

The shape of the orifice in the regulating valve can be important to how it functions. The standard ball (R-type valve) provides the least sensitive regulation, whereas other variations on the orifice shape allow for more sensitive regulation of flow.

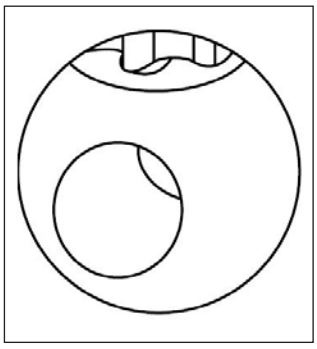
Figure 2 Ball regulating valves.



TeeJet RL-type ball 'special shaped ball' RL balve ▲



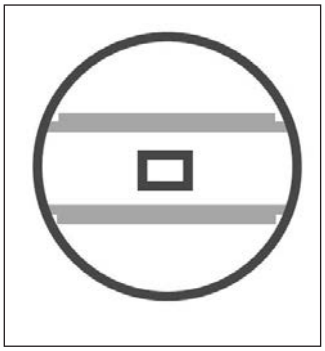
TeeJet PR-type ball 'vee shaped ball' PR valve ▲



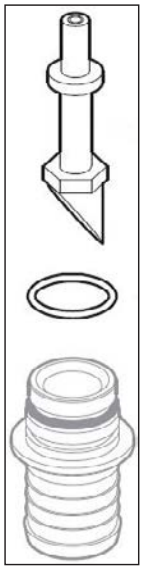
TeeJet R type ball 'standard ball' R-type valve ▲

Source: Teejet® catalogue 51-m

ARAG stainless shaped ball ▲



Source TeeJet® technologies catalogue 51-M ▲



ARAG proportional regulating valve ▶

Source: Teejet®

7.1 Installing regulating valves for different pumps and uses

For **diaphragm pumps**, install regulating valves in **bypass** mode. The regulating valve should be plumbed to the side of the pressure line, before the flow meter, with the bypass flow going back to the top of the tank (see figures 5 and 6, pages 42 and 43 for examples of how regulating valves may be plumbed for diaphragm pumps).

For **centrifugal pumps**, install regulating valves in **throttle mode**.

The regulating valve should be plumbed into the pressure line that is going to the boom valves (see figures 7 and 8, pages 43 and 44 for examples of how centrifugal pumps and valves may be plumbed).

For more information on setting regulating valves, go to Module 6: Pre-operational and regular checks

The only exception to using throttle mode on a centrifugal pump may be when trying to control low liquid flow rates (e.g. liquid systems on seeders or planters). For low flow rates with a centrifugal pump, it is a good idea to install the regulating valve in bypass mode, with the additional flow going back to the top of the tank.

Most self-propelled sprayers do not have a regulating valve in the liquid system, they regulate the liquid flow to the boom by adjusting the hydraulic oil flow to the hydraulic motor on the spray pump.

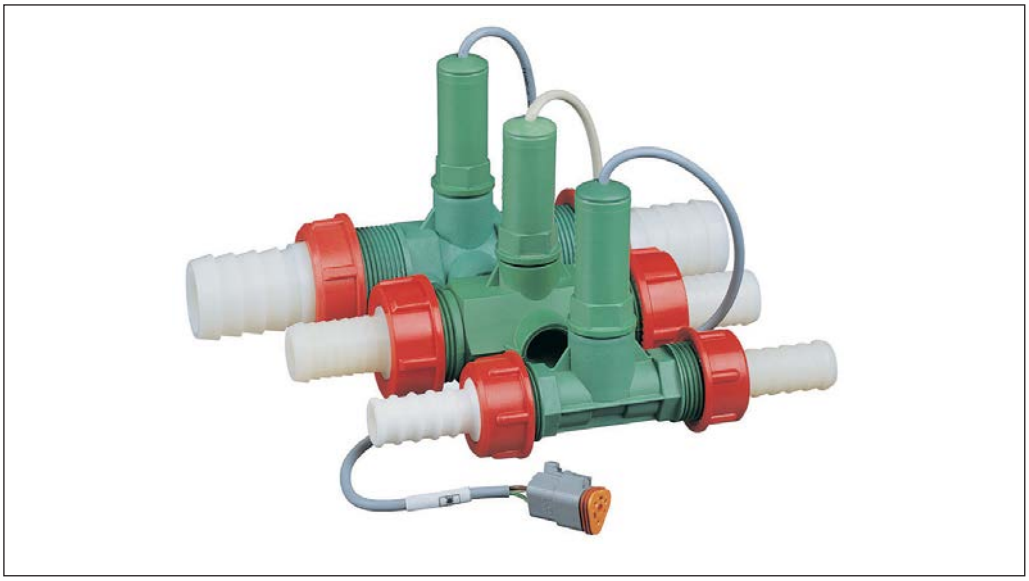
TIPS

- **For liquid systems that use regulating valves, always check the pressure rating of the valve and that the regulating mechanism suits your application.**
- **It is very important to set the position of the 'butterfly' or 'ball' within the regulating valve correctly to get the best out of the sprayer. Performing a pre-field check using the simulated speed function is very important for checking that the valve settings are appropriate.**
- **Avoid using one regulating valve for both filling operations and controlling the sprayer output. A good solution is to two separate systems: one for spraying and agitation, and another one for chemical transfer. Switching between the two systems can be achieved by using continuous flow three-way ball valves to avoid dead-heading either system.**

8. Flow meters

There are two types of flow meters commonly used on sprayers: impeller flow meters and electromagnetic flow meters.

Impeller flow meters come in a range of sizes and flow capacities



Always check the minimum flow requirements for the flow meter match what the sprayer may actually require.

Photo: TeeJet®

8.1 Impeller flow meters

Impeller flow meters have traditionally been the most common flow meters used on sprayers.

As the name suggests, they use an impeller, located in the meter housing, which is mounted on a shaft. As liquid passes over the impeller it rotates and signals or pulses (based on the number of revolutions) are sent to the rate controller to indicate the flow rate of the liquid.

For more information on calibrating flow meters, go to Module 8: Calibration of the spray system

Impeller flow meters will have a calibration factor or figure that may need to be changed to take into account possible changes in the density or viscosity of the product being used.

To maintain their accuracy, impeller-type flow meters need to be serviced regularly by cleaning the impeller and removing any build-up of product, and checking for possible wear of the bearings.

PLAY VIDEO

Plumbing – Mounting of flow meters

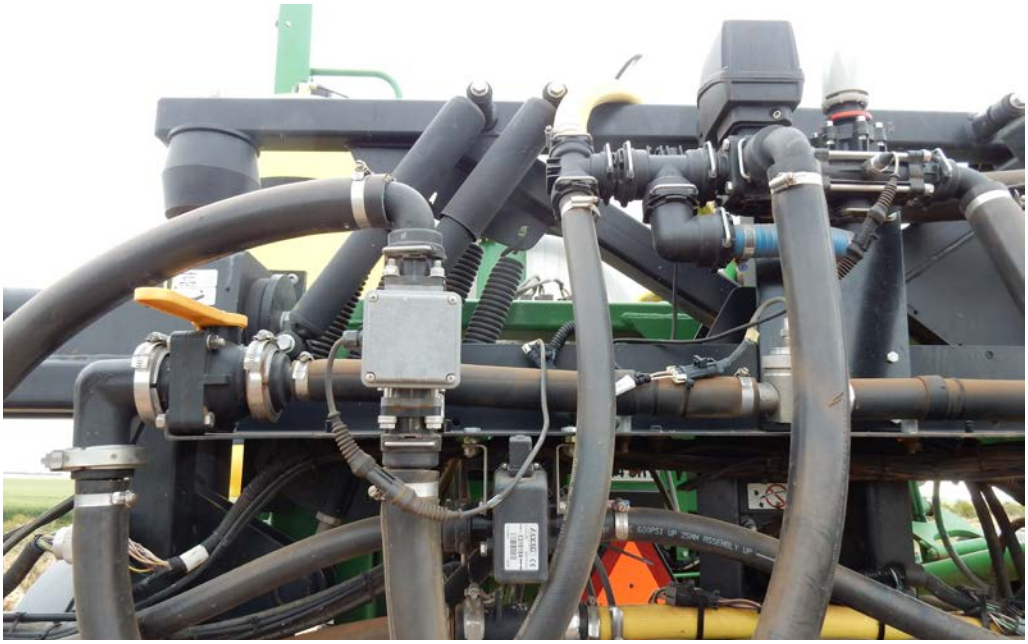
8.2 Electromagnetic flow meters

Electromagnetic flow meters rely on a pulse and have no moving parts. They are less likely to be impacted by the density or viscosity of the spray solution. They are becoming more common on sprayers as operators increase the use of liquid fertilisers and other spray solutions with higher densities.

For the best results when using an electromagnetic flow meter, they should be mounted into the spray line so that the flow meter is orientated vertically (flow coming in the bottom and out the top), ensuring that the sensor is facing sideways (sending pulses horizontally through the liquid).

Mounting the flow meter this way reduces the likelihood that air or turbulence in the spray line will impact on the accuracy of the reading.

ARAG electromagnetic flow meter mounted vertically



Vertical mounting of flow meters improves accuracy and reduces potential blockages.

Photo: Graham Betts

8.3 Consider the lower limit of flow that each flow meter can detect

Most flow meters will have a lower limit of flow that they can detect, which the meter manufacturer will state in the product literature.

If the flow rate through the flow meter drops below the minimum that it can detect, it will not be able to provide information to the rate controller to correctly adjust the sprayer's output.

Low flow rates through a flow meter can create a problem for many spray applicators, especially when the sprayer is fitted with narrow boom sections, or when using an individual nozzle shut-off system, where the flow rates can be particularly low at low spraying speeds.

Where individual nozzle shut-off, or narrow section widths are used, it may be important for the sprayer to be fitted with a rate controller that can utilise **both flow and pressure readings** to enable it to adjust the sprayer's output.

For example, when the flow through the flow meter drops below the minimum that the flow meter can detect, the rate controller is able to switch to using the nozzle pressure to adjust the sprayer's output. When the flow rate through the flow meter comes back into its operational range, the rate controller reverts back to using the measured flow to adjust the sprayer's output.

TIPS

- **Always recalibrate the flow meter after it has been serviced.**
- **Ideally, impeller and electromagnetic flow meters should be mounted vertically, with the outlet at the top and the feed from the bottom, using a length of straight hose (about 10 times the size of the flow meter inlet). This will reduce the possibility of air affecting the flow reading. Mounting the flow meter vertically reduces the chance of product settling in the flow meter.**
- **It is ideal to have a manual ball valve positioned somewhere past the flow meter (e.g. on the end of boom valve manifold) to make it easy to flush the manifold and to make it easy to calibrate the flow meter.**
- **Mount electromagnetic flow meters so the sensor is facing horizontally.**
- **It may be useful for the operator to complete spray plans to work out the required flow range of the flow meter.**

For more information on preparing spray plans go to Module 5: Spray plans

9. Boom valves

There are three different types of boom valves that are commonly fitted to sprayers: solenoids, ball valves and plunger valves.

9.1 Solenoid boom valves with diaphragms

Solenoid boom valves with diaphragms are a common boom valve used on sprayers with narrow booms and are also used to control the nozzle output on the WeedSeeker® (target-selectable sprayer).

Examples include TeeJet® DirectoValve®, Goyen solenoid valves and Texas Industrial solenoid valves.

Most solenoid boom valves generally operate based on a 'two-wire system' comprising a 'signal wire' and a 'ground wire', which allows the liquid flow to turn on and off very rapidly.

Some possible limitations of solenoid valves are:

- they must have power to remain open, which can generate heat in the solenoid;
- they may continue to draw current from the battery if the boom switches are left on; and
- the solenoid's diaphragm may be affected by the formulation type of the products used, which can limit the flow rate.

9.2 Ball boom valves

Ball boom valves are commonly supplied with either nylon balls or stainless steel balls. Examples include TeeJet® DirectoValve and Banjo electric valves.

Ball boom valves only need power to open or close the valve, so there is no need for constant power when the valve is off (they will not flatten the battery if the controller panel is left on).

Generally, ball boom valves require a 'three-wire system', comprising 'power', 'ground' and 'signal' wires. More recent wiring looms tend to have three wires to each of the boom valves.

Some older wiring looms (e.g. 'two wire') may require the installation of a dedicated 'power wire' to be able to operate ball boom valves.

TIP

- It is important to match the material that the ball is made of to the product being used, e.g. stainless-steel balls for liquid fertilisers.

9.3 Plunger boom valves

Plunger boom valves are very common on many spraying systems due to their speed of operation and the accuracy of regulation that can be achieved with some models.

Examples of plunger boom valves include: Hardi boom section valves, GEOline® electric section valves and the ARAG Electrovalve.

9.4 Two-way boom valves

Two-way valves are the most common boom valve fitted onto sprayers.

With a two-way boom valve, the flow simply comes into the boom valve and can only go out to the boom (or section). When using two-way boom valves with a manual control system, the pressure in the boom may spike when a boom switch or section is turned off. When using an automatic rate controller with two-way boom valves, the pressure may spike briefly when a boom switch (or section) is turned off. However, the pressure will return to normal once the regulating valve can adjust the flow to match the new overall width.

A TeeJet® 2-way boom manifold

With a two-way manifold, flow can only go from the manifold to the boom section.

Photo: TeeJet®

9.5 Three-way boom valves

Unlike two-way valves, where flow coming into the boom valve can only go out to the boom (or section), with a three-way valve installed when a boom switch is turned off, the flow from the valve goes to a return line back to the top of the tank.

When using three-way boom valves with a manual system, the pressure will remain the same when a boom switch is turned off, provided the correct adjustments have been made to the manual return valve.

A TeeJet® 3-way boom manifold

With a three-way boom manifold, flow can be returned to the tank when a boom section is switched off. The amount of flow returned to the tank is able to be adjusted with some models.

Photo: TeeJet®

When using an automatic spray rate controller with a three-way boom valve, the pressure will remain the same when a boom switch (or section) is turned off. As a result, the regulating valve does not have to make any adjustments to the flow.

Installing three-way boom valves is a good option for most sprayers, provided the controller is able to operate them. However, they may not be directly compatible with chemical injection systems.

Three-way boom valves are very good when using small boom sections, or for systems that have individual nozzle shut-off, because the flow meter does not have to work at the minimum flow it is capable of reading.

When using three-way boom valves, the flow meter reads the total flow, but the controller 'knows' to work out the litres per hectare based on the boom sections or nozzles that are actually turned on.

By setting up the spray system with three-way boom valves, the workload on the regulating valve is reduced, as it only has to respond when there is a speed adjustment.

9.6 Flow-back boom valves

Flow-back boom valves are located on the boom itself. When a boom section is turned off by closing the boom valve (e.g. a two-way boom valve), the flow-back boom valves open to release the pressure from the boom line, returning the liquid flow back to the top of the tank. This type of boom valve allows the non-drip check valves on the nozzles to shut off the spray very quickly.

TIPS

- **Always have a can of contact cleaner on hand, for servicing connections and to troubleshoot electrical faults.**
- **Most boom valve manufacturers use DIN connectors on their boom valves, which makes them easy to install, service and to maintain the electrical connections.**

PLAY VIDEO

Plumbing – matching nozzle spacing, boom recirculation and single nozzle section control

10. Nozzle bodies and mounting

There are two common ways that nozzle bodies can be mounted: as a dry boom mount or a wet boom mount.

Wet boom nozzle bodies are clamped onto a tube (the spray line) and dry boom bodies are connected by hose.

A wet boom nozzle body

Wet boom nozzle bodies are clamped over holes in the boom line. Always check the required hole size for the brand and model selected.

Photo: TeeJet®

10.1 Wet boom plumbing

Wet boom mounting tends to be the prefered way of mounting nozzle bodies on modern sprayers, as this provides for fewer restrictions in the spray line and spray lines are generally easier to decontaminate than with dry boom fittings.

When mounting a wet boom nozzle body to a tube make sure that both the OD of the tube and ID of the nozzle body clamp are accurately measured.

Wet boom nozzle bodies can be supplied to match metric and imperial OD tube. Always check the size of the hole that is required in the tube to match the nipple in the wet boom nozzle body (e.g. 10 or 7 millimetres).

Hardi wet boom stainless-steel plumbing

Wet boom plumbing reduces the opportunity for residues to build up in the spray lines.

Photo: Graham Betts

10.2 Dry boom plumbing

Dry boom nozzle bodies can be mounted onto round pipe or RHS steel, using nozzle body clamps (see examples below).

A dry boom nozzle body

Choose dry boom nozzle bodies with the largest hose barbs available.

Photo: TeeJet®

Always select dry boom nozzle bodies with the largest hose barbs available.

When connecting the dry boom nozzle bodies with a hose, always select an appropriate hose type that is rated for use with agricultural chemicals.

Dry boom plumbing

Dry boom plumbing introduces more restrictions to flow and places where product may become trapped in the spray lines.

Photo: Graham Betts

Figure 3 Examples of dry boom clamps to hold nozzle bodies.

QJ111 QJ111SQ AA111 AA111SQ

Source: TeeJet® Technologies Catalog 51-M

Go to: www.teejet.com/literature_pdfs/catalogs/C51A-M/cat51a_metric.pdf

TIP

- Try to avoid dry boom plumbing sections that are too long for the hose diameter as pressure drops will occur across the boom. Consult a table that shows the pressure drop through various lengths of hose of different diameters, such as in the TeeJet Catalogue 51A-M

11. Non-drip check valves

Always check the pressure rating of non-drip check valves before purchase or installation.

A TeeJet® non-drip check valve

Always check the pressure rating that the non-drip valves will open and close at.

Photo: TeeJet®

One of the causes of nozzle bodies that are slow to shut off, or that continue to drip after the boom section has been turned off, could be the pressure rating of the non-drip check valve. Some non-drip check valves are rated to open at pressures as low as 0.75 bar.

It is very useful to have the highest pressure rated non-drip check valve that will match the nozzle types being used and the minimum setting on the rate controller (e.g. a 2.0 bar rating for use with low-pressure air-induction nozzles).

An alternative to the check valve is to use either an electric nozzle shut-off or an air nozzle shut-off system. Both electric and air shut-off systems provide positive shut-off and turn-on for the nozzles.

12. Number of outlets on the nozzle body

Operators will generally be offered a choice by the sprayer manufacturer regarding the number of nozzle outlets they require per nozzle body. Nozzle bodies are commonly available with one, two, three, four or five outlets.

Five-nozzle body

Multiple nozzle bodies are very useful, but require maintenance.

Photo: Bill Gordon

There are strengths and limitations to using multiple-outlet nozzle bodies. One of the greatest benefits of having multiple nozzles fitted on the one nozzle body is the ability to easily change the nozzle type or orifice size to match the product or tank mix, the conditions, and the operating parameters.

One of the possible limitations to using multiple-outlet nozzle bodies is that they can become contaminated, dirty or blocked if the 'turn-over' or 'rotation' ability is not used regularly, or the outlets are not covered by a nozzle and cap or a blanking cap during spraying operations.

When rotating nozzle bodies become hard to turn, they need to be pulled apart, washed in hot soapy water and re-installed using an appropriate lubricant.

TIPS

- Nozzle manufacturers make manual shut-off check valve assemblies, which may be useful for turning a selection of nozzles on and off. For example, manually shutting off half the nozzles when alternating between narrow nozzle spacings and wide nozzle spacings (e.g. going from 0.25m spacing for fungicide applications to 0.5m for fallow spraying).
- If the nipple is broken in the wet boom body, find some tube of the same size, drill out the broken nipple and glue the new piece of tube into the nozzle body.

PLAY VIDEO

Benefits of boom re-circulation

13. Boom re-circulation

The main reason to consider boom re-circulation is the ability to prime the boom line with the tank mix before having to turn the nozzles on. This eliminates the need to flush the tank mix through the boom line in the paddock.

Boom re-circulation is also very useful to reduce the likelihood of products settling out in the boom line when the nozzles or boom sections are turned off as the spray solution in the boom lines can be returned back to the tank.

Manual boom re-circulation

Re-circulation allows booms to be primed before turning the nozzles on

Photo: Graham Betts

A possible drawback to having a boom re-circulation system is the possibility that diluted product may be returned back to the main spray tank, which makes most re-circulation systems incompatible with direct-injection systems.

13.1 Setting up boom re-circulation

The general idea for a re-circulation system is to have a return line from the end of each of the boom sections that takes liquid back to the top of the tank. This will keep the tank mix products circulating when the nozzles are turned off.

Normally this can be achieved by having a common return line that runs along the boom to the top of the tank, where each of the boom section return lines are plumbed into using T-pieces.

Using re-circulation requires that the nozzles are able to be shut off to prevent flow coming out of the nozzles while the re-circulation is engaged.

There are a range of air shut-off nozzle bodies and electric shut-off nozzle bodies that can turn off the nozzles while allowing liquid to flow through the boom section.

Electric nozzle shut-off valve

Check the current draw for electric nozzle shutoff valves before installation, particularly for wide booms.

Photo: Teejet®

An alternative system to allow flow to return to the tank while the nozzles are shut off is to fit non-drip check valves that only open at higher pressures (e.g. rated to open at a minimum pressure of 2.0 bar); this way liquid can be re-circulated at lower pressures (1.0 to 1.5 bar) without the nozzles opening.

To be able to control the 'engagement' or 'disengagement' of the re-circulation system requires that a valve be installed between the end of each boom section and that the flow from the section is fed into a common return line to the tank when the valve is opened.

It is also useful to have an additional valve at the end of the common return line, just before the return line enters the tank. This allows the common return line to be isolated if repairs or decontamination are required. As with other plumbing on the sprayer, it is important to use fly-nut-and-tail fittings to make access, servicing and maintenance easier.

There are three options for setting up a boom re-circulation system, the only difference between the three options is the types of valves that may be used (see Figure 4).

Figure 4 An example of how boom re-circulation can be plumbed.

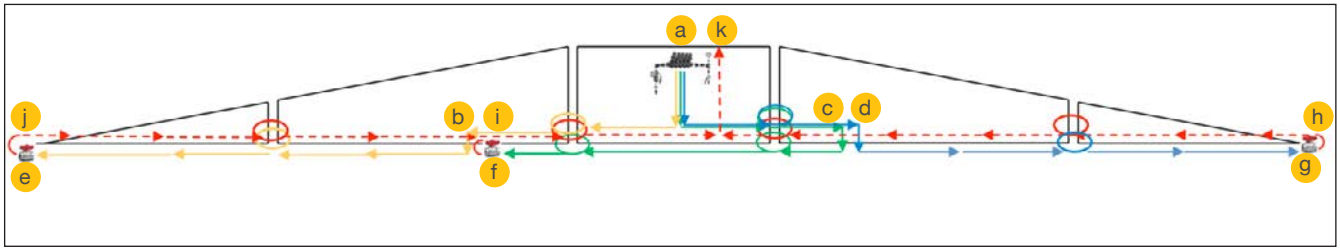


Table 3 Components and tips for installing a re-circulation system.

Position in the diagram above, component or fitting type and plumbing tips			
Position	Fitting or component	Description	Plumbing tips
a	Boom valves	Boom valve manifold	
b	Pressure hose	From boom valve one to boom section one	Plumb the flow into each boom section into one end of the boom section, not into the centre of the boom section.
c		From boom valve two to boom section two	
d		From boom valve three to boom section three	
e	Ball valve	Flush tap on the end of boom section one	Use ball valves on the opposite end of each boom section to the liquid feed, these can act as a flush tap.
f		Flush tap on the end of boom section two	
g		Flush tap on the end of boom section three	
h	Return hose	Boom 3 return line	Use a minimum of 1" hose as the return line. Use fly-nut-and-tail fittings to make servicing easier. T boom section two, flush tap into the return line from boom section one.
i		Boom 2 return line	
j		Boom 1 return line	
k		Return line back to the top of the main spray tank	

13.2 Options for setting up a re-circulation system

The basic option – manual ball valves

Establish a common return line that runs along the booms and back to the top of the tank.

Manual return line into the top of the tank

Photo: Graham Betts

Install manual ball valves (with a 'butterfly handle') at one end of each boom section (opposite end to the feed).

End of boom manual boom re-circulation

A basic version of boom re-circulation using manual valves is easy to install.

Photo: Graham Betts

Along the boom manual boom re-circulation

Electric valves make it easier for the operator to engage and disengage the re-circulation system.

Photo: Graham Betts

Attach a return line for each section into the common return line. This should run from the manual ball valve to a T-piece installed into the common return line.

Between the common return line and the top of the tank, install another manual ball valve close to the tank.

Manual return line into the top of the tank

Photo: Graham Betts

The basic electric option

Set up the plumbing as in 'basic option', with manual ball valves at the end of each boom section.

Replace the manual ball valve at the top of the tank with an electric ball valve (at the end of the return line).

The best option

Set up all the plumbing as in 'basic electric option', with electric ball valves at the end of each boom section, and an electric ball valve on the return line at the top of the tank.

Along the boom electric boom re-circulation

Electric valves make it easier for the operator to engage and disengage the re-circulation system.

Photo: Graham Betts

End of boom electric boom re-circulation

Electric valves allow the re-circulation to be engaged or disengaged from the sprayer cab.

Photo: Graham Betts

13.3 Re-circulation ball valve positions for different purposes

Ball valve positions when priming the boom

Turn the ball valves located at the end of the boom sections and at the top of the tank to the 'open' position, then, with the pump operating, turn each of the boom sections switches in the controller to the 'on' position.

If the sprayer has non-drip check valves on the nozzle bodies to prevent flow (e.g. rated to open at 2.0 bar), ensure there is only 1.0 to 1.5 bar pressure in the spray line to ensure the nozzles do not start to spray.

Ball valve positions when spraying

Just prior to spraying after, the boom is primed, unfolded and turn the boom sections to switch off position at the controller (to stop the re-circulation).

Turn the ball valves at the end of the boom sections to the 'closed' position. This will cause the spray solution to come out of the nozzles once the switches to the boom sections on the controller are turned on again.

Click to go to the Hypro website: legacy.hypropumps.com/en-us/Tools/SelectionGuide/

Ball valve positions when flushing the system

If the tank is empty at the end of a spray job, clean water from the flush tank may be used to flush the re-circulation system; however, this will send some diluted product back to the tank.

Turn the re-circulation valves at the top of the tank, and at the end of each boom section to the 'open' position. (Check the system pressure if using non-drip check valves to stop flow from the nozzles.)

Turn the boom section switches in the controller 'on' and flow will now return to the tank.

Disconnecting return lines for decontamination

After adding an appropriate decontamination agent to the tank, use the re-circulation system while agitating the tank. Allow the cleaning products to stay in the tank and re-circulation system for an appropriate amount of time, then drain the tank and rinse with clean water.

After rinsing and draining the tank, avoid any product remaining in the re-circulation system returning to the tank. Disconnect each of the boom section return lines from the valves at the end of each boom sections to allow for an open flow (this may be done by removing fly-nut-and-tail). Engage each boom section switch on the controller, one at a time, to maximise flow through each section of the boom.

For more information go to: Module 7: Mixing and decontamination requirements

Once the boom sections have been flushed with clean water, reconnect the return lines to the valves at the end of the boom sections and disconnect the common return line from the ball valve at the top of the tank, then flush clean water through the common return line.

The decontamination agents and number of flushes should follow the procedures outlined in Module 7, ‘Mixing and decontamination requirements’.

14. Hydraulics for the pump and plumbing system

Hydraulic drive is the best way to drive a diaphragm pump as there are generally too many issues with using PTO-driven shafts, particularly for the safety of the operator.

Diaphragm pumps (540 RPM models) that are hydraulically driven need to be set up so they cannot be run below a minimum of 450 RPM or above a maximum of 540 RPM. Operators should install a fitting on the hydraulic drive block so that the pump cannot be run over 540 RPM no matter what the hydraulic setting or oil pressure is.

Centrifugal pumps may not be able to perform as intended if the hydraulic plumbing is not correctly set up or adjusted. Hydraulic motors on hydraulic centrifugal spray pumps need to be matched to the hydraulic capacity and system of the tractor.

Go to Hypro website: http://legacy.hypropumps.com/en-us/Tools/SelectionGuide/

Always check the pump manufacturer's website for the most appropriate model of hydraulic motor to match the tractor model or hydraulic oil flow capacity of the sprayer.

When establishing the hydraulic plumbing to and from the hydraulic motor on the spray pump, it is very important to have a ¾" hydraulic hose going back to the dedicated 'motor return RET' fitting on the tractor, not the 'case drain TANK'.

Plumbing the hydraulics correctly can reduce the back pressure, which needs to be no greater than about 50 psi. This will help to reduce heat build-up and will extend the life of the seals in the hydraulic motor.

While it is not common practice, some centrifugal pumps can be operated at pressures of up to 10.0 or 12.0 bar, provided the hydraulic plumbing is correctly selected and installed.

TIP

- **When connecting the hydraulics always connect the return hose first and the pressure hose last and do the opposite when disconnecting the hydraulics: remove the pressure hose first and the return hose last.**

PLAY VIDEO

Calibration – trailing rig pressure gauge

15. Pressure gauges

It is important to have two pressure gauges on each spray rig. One of the pressure gauges should be used to show the spray operator the pressure at the pump and the other used to show the pressure at the nozzle.

The gauge showing pressure at the nozzle can be a digital readout in the cab, with the sensor mounted as close to the nozzles as possible (e.g. from the boom line). If using a liquid pressure gauge, the gauge should be mounted outside of the cab, ideally near the windscreen. The ideal liquid pressure gauge would be at least 100mm (3.94”) in diameter, with the preferred operating pressure displayed at the top of the dial.

Outside windscreen pressure gauge

Having a gauge outside the cab reduces risk to the operator.

Photo: Graham Betts

TIPS

- **Large differences in pump pressure and nozzle pressure may indicate restrictions in the spray lines due to poor plumbing or blocked filter screens.**
- **Plumb liquid pressure gauges into a T-piece, with a manual ball valve at one end, to allow the gauge to be primed and flushed.**

16. Boom section control

PLAY VIDEO

Introduction to section control and width

There are section-control systems available that can control either multiple boom sections or individual nozzles.

The number of boom sections is generally only limited by the number of boom switches and boom valves fitted to the sprayer, and the ability of the section-control system or the rate controller.

For multiple boom sections, the boom section control is generally done using a boom valve manifold.

Twelve-section boom valve manifold

When using boom valves to control the sections, allow for extra outlets for fenceline nozzles.

Photo: Graham Betts

PLAY VIDEO

Auto section control & chemical savings

While multiple boom sections that are coupled with auto-section control can be useful for reducing overdosing of the boom overlaps, individual nozzle section control is even better for this purpose.

Individual nozzles are usually turned on or off using either an air shut-off valve at the nozzle bodies or by using electric shut-off valves at the nozzle bodies. This may be controlled by a standalone automatic section controller, or may be integrated into some rate controllers.

Individual nozzle shut-off

Electric and air nozzle shut-off valves provide an instant 'on' and instant 'off' for the nozzle flow.

Photo: TeeJet®

17. Examples of common plumbing configurations and tips

Unfortunately, many of the ways that sprayers get plumbed do not allow all of the components to work as they were intended.

Figures 5, 6, 7 and 8 provide examples of how different pump types and valve configurations can be plumbed to ensure each component works efficiently.

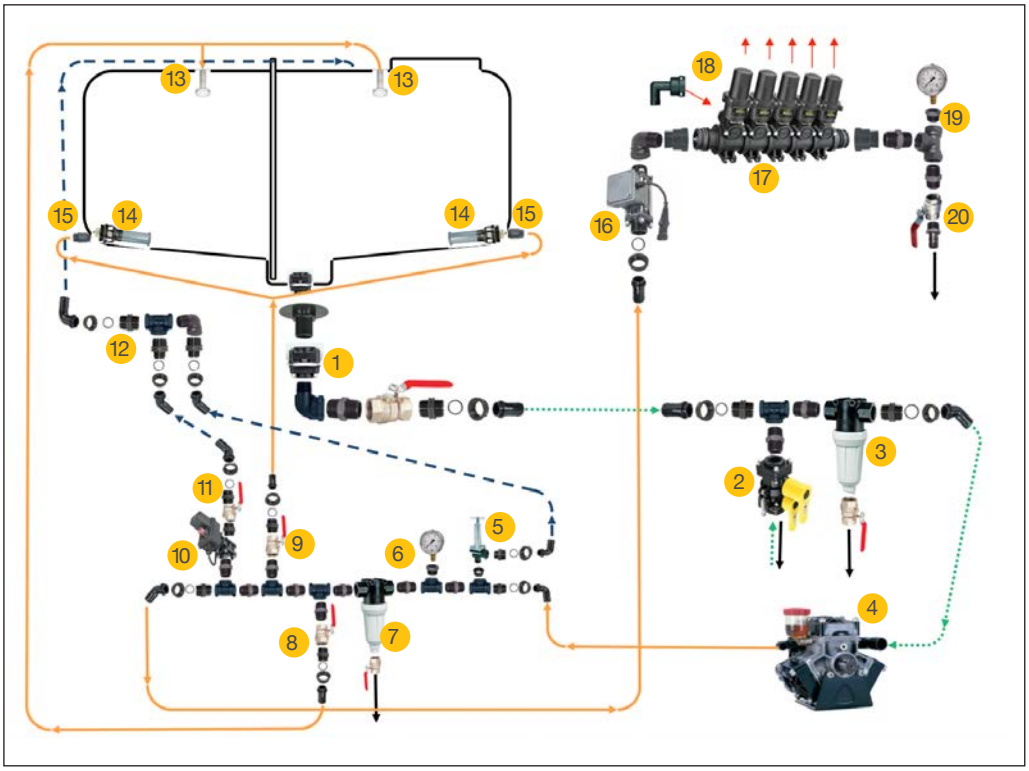
Figure 5 provides an example of a positive-displacement (diaphhragm) pump plumbing set-up with two-way boom valves.

Figure 6 provides an example of plumbing a positive-displacement (diaphhragm) pump set-up with three-way boom valves.

Figure 7 provides an example of a centrifugal pump set-up with two-way boom valves.

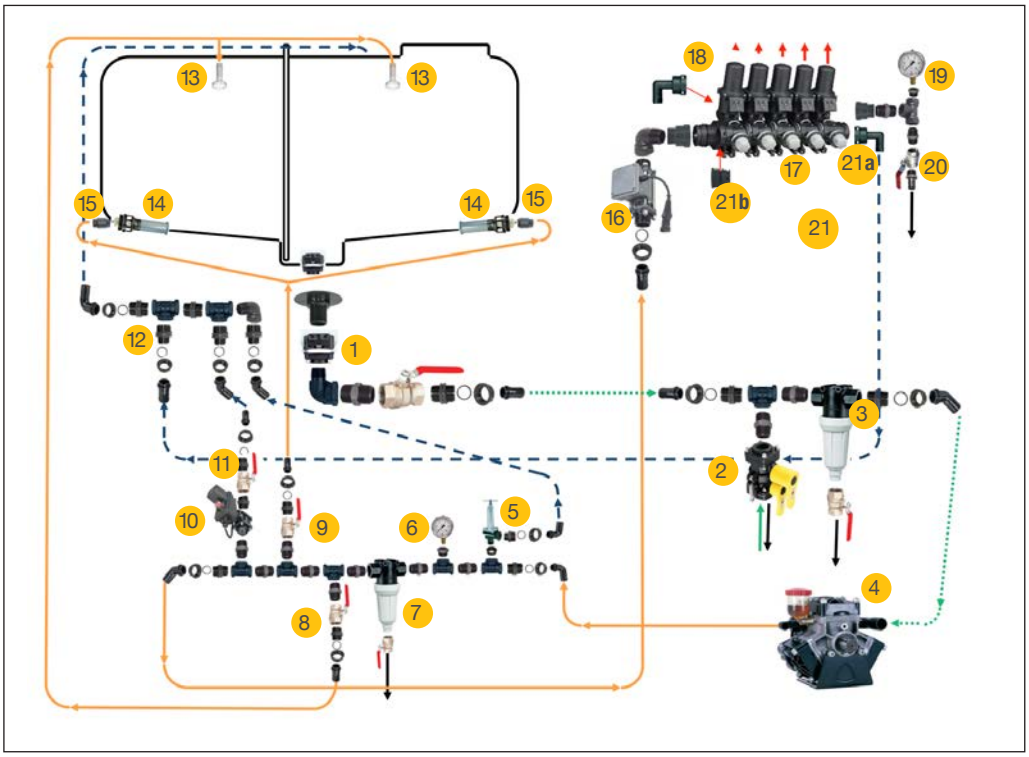
Figure 8 provides an example of a centrifugal pump set-up with three-way boom valves.

Figure 5 Plumbing for a positive-displacement pump with two-way boom valves.



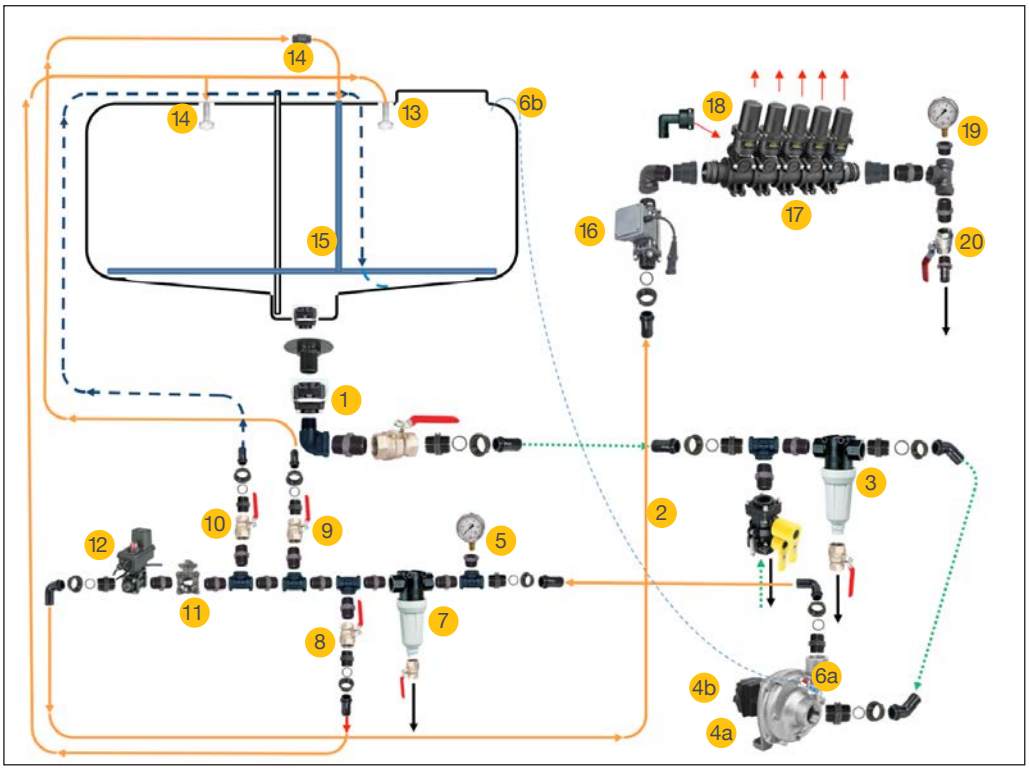
See table of components pages 45-48

Figure 6 Plumbing for a positive-displacement pump with three-way boom valves.



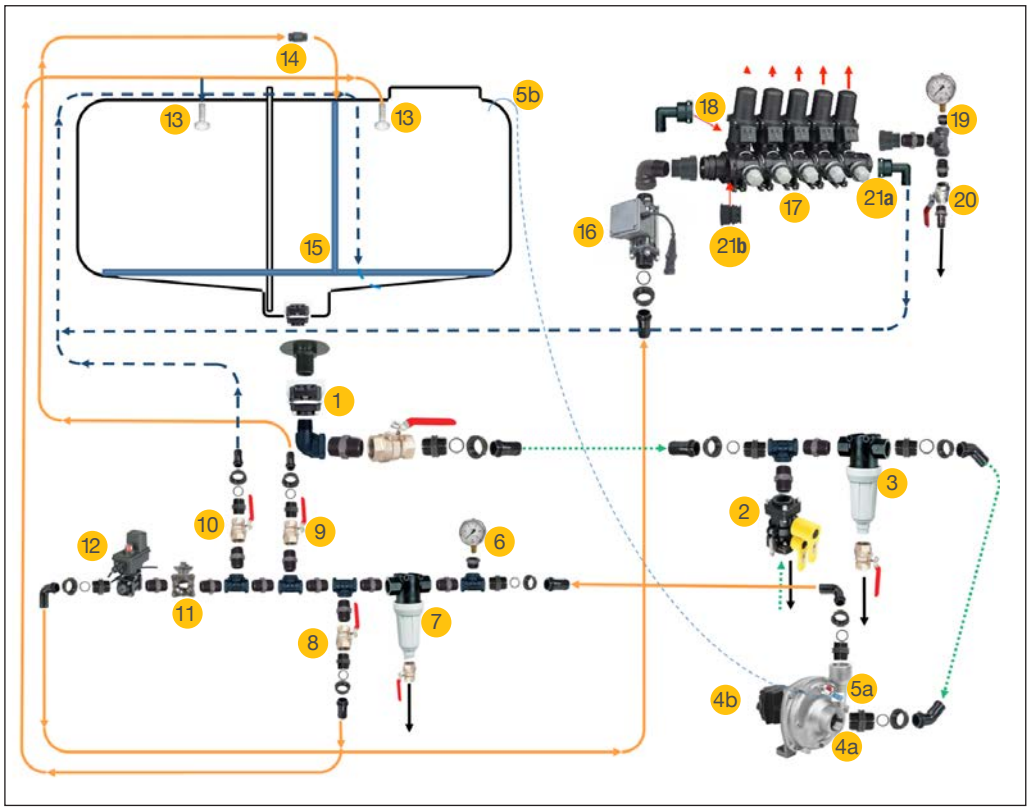
See table of components pages 45-48

Figure 7 Plumbing for a centrifugal pump with two-way boom valves.



See table of components pages 45-48

Figure 8 Plumbing for a centrifugal pump with three-way boom valves.



See table of components pages 43-46

Table 4, page 45 to 48 identifies and describes the components listed in figures 5, 6, 7 and 8 and lists tips for their installation.

Table 4 Components and tips for Figures 5, 6, 7 and 8.

This table gives an explanation of figures 5, 6, 7 and 8 diagrams page 42-44.
Note that some components are common to all systems while other components are specific to positive-displacement pumps (e.g. diaphragm pumps) or to centrifugal pumps.

Position	Fitting or component	Description	Plumbing tips
Main spray tank	Holes for fittings	It is ideal to have a single hole at the base of the sump for the tank outlet. Where Venturi agitators are fitted, an additional hole may need to be installed on one of the ends at the base of an elongated tank.	All other holes, including holes for sparge agitators, should be placed into the top of the tank. Having hoses in the side of the main tank makes it hard to isolate the main spray tank if there is a problem, and creates risk if a tank fitting on the side of the main spray tank comes loose or leaks.
1	Tank outlet	It is ideal to use a bottom drainbolted tank flange e.g. Banjo so the tank can be drained dry and to have the same size or larger fittings than the suction fitting on the pump (usually about 2.0”).	Install an anti-vortex fitting in the top of the tank outlet to help reduce the chance of the pump sucking air when the tank is low. Install a manual ball valve on the tank outlet so the main spray tank can be isolated if there is a problem with the sprayer. Use an easy-to-remove fitting to connect the suction hose to the manual ball valve e.g. ARAG nut-and-tail, TeeJet® and/or Banjo flange system.
2	Tank fill and drain ‘dry connect fitting’	This is a simple way of plumbing, and may be risky in that product may become caught in the drain hose, which only gets removed when the tank is flushed. It may be a good idea to have a single hose for suction, tank fill and drain, but when installing these fittings, they will need to have a one-way or check valve installed.	Do not use stag or silastic on threads, use pink plumber’s tape and a thread sealant. Check that hoses are rated as chemical hoses, working pressure is chemical working pressure (not water pressure). Use two different types of hose, one for suction and a different type for pressure. Use flanged and/or fly-nut-tail fittings to solid mount to hose connections.
3	Positive displacement only Suction filter	Suction filter set-up for a positive displacement pump. The filter screens for a positive displacement pump can be 30 or 50 mesh.	Match the filter size and fittings to the pump capacity or larger. It is ideal to have a suction filter bowl so the filter can be flushed easily without removing the bowl. Install a manual ball valve just before the suction filter so the main spray tank can be drained. This is to reduce the possibility of having product caught in the suction hose. It is common to have a T-piece on the tank outlet with a hose going to suction filter and another hose going to a drain tap using a manual ball valve.
3	Centrifugal only Suction filter	Suction filter set-up for centrifugal pump. The filter screens can be 16 mesh.	
3	Centrifugal only Suction filter	Suction filter set-up for centrifugal pump.	If the drain tap is installed in the pump suction line, there is a reduced chance of product being left in the drain hose when the spray pump stops pumping out of the main spray tank.
4	Positive displacement pump	it is very important to have a ¾” hose on the return line from the hydraulic motor connected to the ‘return’ location on the tractor, NOT to the ‘remotes’. The ¾” hydraulic fitting will make connecting the hydraulics easier.	Check the level and colour of the pump oil before starting to use the sprayer, and each time you are filling the spray tank. Generally, pumps may give you a bit of warning when a diaphragm is cracking by the colour of the oil, so checking the oil bowl each time you fill the spray tank may save the expense of wrecking the spray pump.

Position	Fitting or component	Description	Plumbing tips
4	Centrifugal pump	It is very important to have a ¾" hose on the return line from the hydraulic motor connected to the 'return' location on the tractor, NOT to the remotes. The ¾" hydraulic fitting will make connecting the hydraulics easier.	It is important to have a vent line from the top of the pump volute to the top of the main tank. A stopcock could be installed at the pump with 8mm command tube going to the top of the tank. The only time the stopcock may need to be turned off is when decontaminating the boom spray. When connecting the hydraulics, connect the return hose first and the pressure second. When disconnecting the hydraulics, disconnect the pressure hose first and the return hose second.
5	Positive displacement only Pressure relief valve	Install the pressure-relief valve before any other spray components, especially filters. If a diaphragm pump is dead-headed, the liquid has to go somewhere, and it will find the weakest point in the plumbing system or pump.	Match the pressure-relief valve to the maximum pressure of the pump. Having a higher rated pressure-relief valve than the maximum pressure of the pump may cause the pump to be dead-headed. Never connect the bypass of a pressure-relief valve to the agitator.
5a	Centrifugal only vent line	Vent line with stopcock at the pump.	Always read the manufacturer's instruction manual for the installation of a vent line to the centrifugal pump.
5b	Centrifugal only vent line	Vent line at the top of the tank.	
6	A pressure gauge	A pressure gauge on the pressure side of the pump before the filter.	A pressure gauge on the pressure side of the pump before the filter is good as a troubleshooting tool and for setting the bypass manual ball valve and throttle valve positions correctly.
7	Pressure filter plumbing	Pressure filter. Match the pressure filter screen to the product being applied, or an 80-mesh filter could be a standard screen mesh size.	It is a good idea to have a manual ball valve on the bottom of the filter bowl to make it easier to flush the filter and screen.
8	Manual ball valve	Manual ball valve to tank rinse nozzles.	This allows the rinse nozzles to be manually isolated.
9	Manual ball valve	Manual ball valve to agitators.	This allows the agitators to be manually isolated.
10	Electric regulating ball valve	Electric regulating ball valve in bypass position/mode.	Regulating valves must be in the bypass position so the pump or system cannot be dead-headed.
11	Manual ball valve on the end on the regulating valve	Manual ball valve is installed in case the regulating valve has failed so that the nozzle pressure can be set manually, or for troubleshooting.	Having a manual ball valve is useful for forcing the system to have a minimum setting (or flow to the boom) if there is not already a minimum setting function in the rate controller model fitted to the sprayer, e.g. Hardi Pilot.
12	Bypass hoses manifold	Install a bypass hoses manifold so there is only one hose going to the top of the main spray tank, and to assist with trouble shooting.	If you having a problem with the sprayer you can undo the fly-nut-and-tail and see if liquid is coming or not coming from each individual hose. If the bypass hoses are T 'd into one hose, it can be hard to work out which spray component is not working properly.

Position	Fitting or component	Description	Plumbing tips
13	Tank rinse nozzles	With rectangular spray tanks, it is optimum to have two tank rinse nozzles to have a better distribution for a tank that is narrow one way and long the other way.	Use the tank rinse nozzles to reduce the foam in the spray tank during filling and agitation.
14	Positive-displacement agitation	Venturi agitators are a good option for positive-displacement pumps, but take care to match the agitator(s) to the operating pressure. The most common Venturi agitators have a minimum operating pressure of 5.0 bar. If operating at low pressure it may be a good option to use a sparge agitation system.	Use two agitators, one each side of the tank to improve the swirl of liquid in the spray tank. Have a one-way or check valve on the agitator so the spray tank can be isolated when checking plumbing on the sprayer. It is a good idea to have a dedicated agitation pump so agitation is not compromised. This is critical for large main spray tanks.
14	Centrifugal agitation	When using a centrifugal pump, agitation is best done using a sparge agitator. A sparge agitator is a piece of tube on the floor of the tank with holes drilled along each side. It is best to come in from the top of the tank as per figures 7 and 8.	On sprayers with large main tanks, it is a good idea to have a dedicated agitation pump, so the agitation of the tank mix is not compromised.
15	One-way / check valves	One-way/check valves to isolate the spray tank	One-way/check valves help to prevent contamination.
16	Flow meter	The flow meter can be attached to the boom valve manifold. On the opposite end of the boom valve manifold install a T-piece.	Mount the flow meter vertically with a straight length of hose coming into the bottom of the flow meter.
17	Two-way boom valve manifold	Modern boom valves have three wires power, signal and ground. You may need to add a power wire to the wiring harness.	Mount the boom valves at the back of the sprayer on the boom centre. This will allow you to have one large spray line going from the pressure manifold to the back of the sprayer (instead of many smaller boom line hoses going from the pressure manifold to the back of the sprayer).
18	Boom valve hose tails going to the boom sections	Mount the boom valves on the boom centre at the back of the sprayer.	Have boom valves dedicated to fenceline nozzles. The fenceline can rob flow and pressure out the boom section if they are plumbed into a boom section. A boom valve dedicated to a fenceline nozzle can be used as a spare boom valve if one of the other valves fails; just swap the hose tail and electric wiring. You may need to use different size hose diameters on various sections to maintain a constant pressure at the nozzle. Things that can cause pressure drops are the length of hose to the boom section or the number of (or lack of) nozzles on a boom section.

Position	Fitting or component	Description	Plumbing tips
19	T-piece	Install a fitting in the top of the T-piece that is on the end of the boom valve manifold. The top of the T-piece is used for gauge, electronic pressure sensor or fitting for 8mm airline or command tube. The tube goes to a 100mm pressure gauge outside the windscreen.	Run at least 100L through the flow meter when performing a flow meter calibration.
20	Manual ball valve	Install a manual ball valve on the bottom of the T-piece so the boom valve manifold can be flushed.	The ball valve will allow the flow meter to be calibrated and help with troubleshooting.
21a	The bypass manifold	The bypass manifold is part of the three-way boom valve. Bypass hose goes to the bypass manifold.	Three-way boom valves do not work well with direct injection. If using three-way boom valves on a direct-injection system have a manual ball valve on the bypass line.
21b	Plug for end of bypass manifold	Always plug empty sockets or outlets.	

18. General plumbing tips for installing hoses and fittings

Always try to reduce all possibile 'blind spots' where product may become trapped, never use reducing nipples or T-pieces on the inlet or outlet of a pump.

To ensure components are easy to access and maintain, consider using some of the following tips.

General plumbing tips for the spray operator

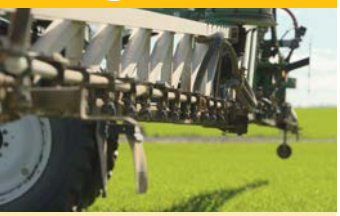
Fittings

- It is preferable to have fittings that are easy to remove for installation, maintenance and repairs, such as Banjo®, GEOLine or ARAG® fittings.
- Where two fittings need to be screwed into each other, use thick (pink) plumber's tape and thread paste to make sealing, adjustment and removal easier. **Do not** use silastic-type products or stag. Silastic is hard do anything with if there is a leak, and fittings that have been put together with stag are very hard to get apart.

Hose clamps

- Use good-quality stainless steel hose clamps with a solid band. It is a good idea to spray lubricant onto the hose clamp before trying to adjust them, new or old. It is easier to tighten a hose clamp if you apply lubricant, unscrew the clamp for a bit and then tighten. If you try to tighten the hose clamp without doing these steps, you may not get the clamp as tight as you need.

PLAY VIDEO



Plumbing – section width and potential pressures

Hoses

- Make the sprayer plumbing simple as possible, always try to reduce the amount of hose used, and reduce or eliminate blind spots.
- The TeeJet Catalogue 51- M (http://www.teejet.com/literature_pdfs/catalogs/C51A-M/cat51a_metric.pdf) includes useful information on pressure drops through various hose diameters related to the length of hose and the flow rate.
- Hose with crossover webbing is good for going around bends due to its flexibility. However, it can expand too much when being pressurised or de-pressurised if the pressure rating is not high enough. The result of the hose expanding may be that it takes a while for the nozzles to come on (because the hose needs to expand) and the nozzles can take a while to shut off (because the hose needs to contract to original size).
- Use hose that is the same size or larger than the fittings on the pump.
- Use a hot-air gun to make removing hose from fittings easier and boiling water to install hose on fittings. **Do not** tighten hose clamps before the hose has cooled off.

PLAY VIDEO

Fenceline nozzle

Components

- To make plumbing easier it is best to make up separate manifolds rather than try to put all spray components into a single manifold.
- Use nipple, fly-nuts-and-tails e.g. GEOline and ARAG® fittings and/or flange fittings e.g. Banjo® Manifold Systems, TeeJet® DirectoValve Flange Fittings. These fittings make it easy to make minor changes to the sprayer when conducting maintenance or repairs to the sprayer's plumbing.
- Install a pressure gauge outside the windscreen of the sprayer or spray tractor that is connected as close to the nozzles as possible. Leave the other pressure gauge at the front of the sprayer (on the pressure line from the pump) so the operator knows what the pump pressure is.
- Use filters (suction and pressure) that have a thread on the bottom of the bowl for the installation of a manual ball valve to make flushing easier between dismantling the filter or cleaning the screen.

19. Summary

It is important that the spray operator can access all of the components that require regular maintenance or calibration. This includes the ability to isolate the main tank from the rest of the spraying system when required.

Before purchasing or installing any new component, carefully consider what the flow requirements will be for the range of application volumes (L/ha) and spraying speeds likely to be done. This will help to identify the most appropriate components, such as pumps, flow meters and valves.

This module has tried to provide an overview of how the spraying system can be set up to ensure each of the components works as it is intended to, along with many tips to make the installation and operation smoother.

For further information on specific components, always refer to the literature supplied by the product manufacturers.

NEXT MODULE

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 12 GPS systems The options available

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