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PERFORMANCE THROUGH ENGINEERING

HydroWhirl® Orbitor 100
Tank Washing Machine

Instruction and Maintenance Manual

BETE Fog Nozzle Inc.
www.bete.com

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Introduction to the Orbitor 100 Tank Washing Machine

This document is the Installation, Operation and Maintenance Manual, also known as the Product Manual, for the Orbitor 100 Tank Washing Machine (TWM). These machines are supplied for use in the marine, industrial, and food processing industries.

Component Names

For part numbers and names see the Maintenance Manual section starting on page 20. The figures shown throughout the manual are typical of a 4 nozzle machine. These examples may not directly resemble the machine supplied but are fundamentally the same in construction and part materials.

Operation Principles

The basic tank cleaning process is achieved by impinging high impact cleaning fluid jets on the inner walls of the vessel. The TWM action moves the jet nozzles in a spiral pattern that ensures correct and even coverage of the vessels surfaces through a washing cycle.

The flow of the cleaning fluid drives the machine causing the spherical body and nozzle head to rotate. There are no other power sources, control systems or electrical devices. The mechanism is self-lubricated and internally self-cleaned by the cleaning fluid. Three small fixed jets wash the machine exterior. The Orbitor 100 TWM can be used with pressures as low as 45 psi (3 bar) due to a very low starting torque.

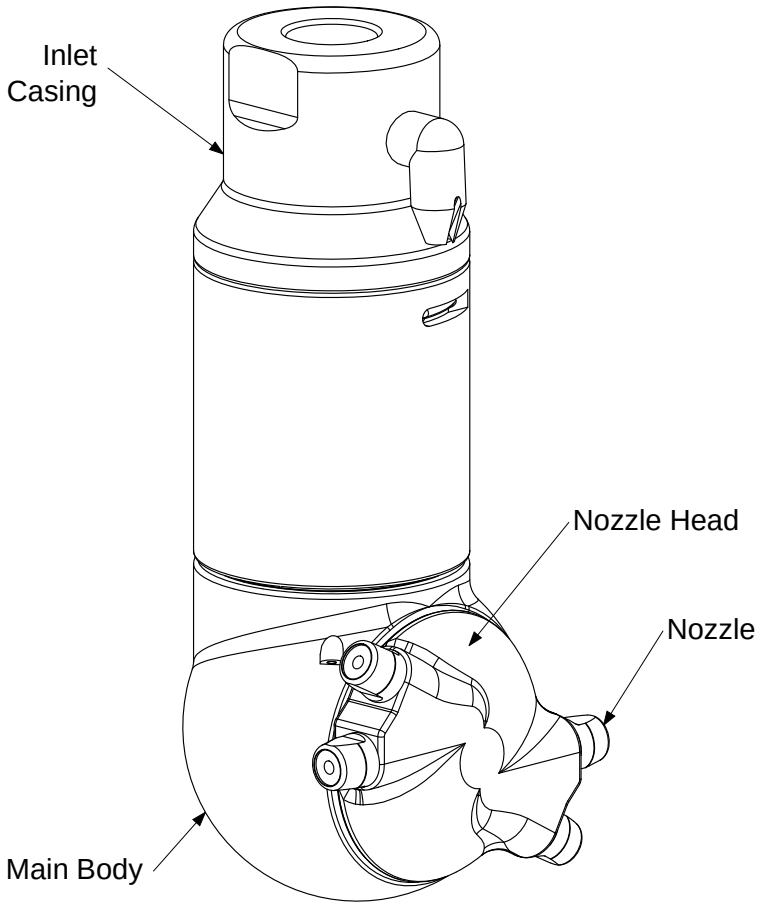

Figure 1: General arrangement.

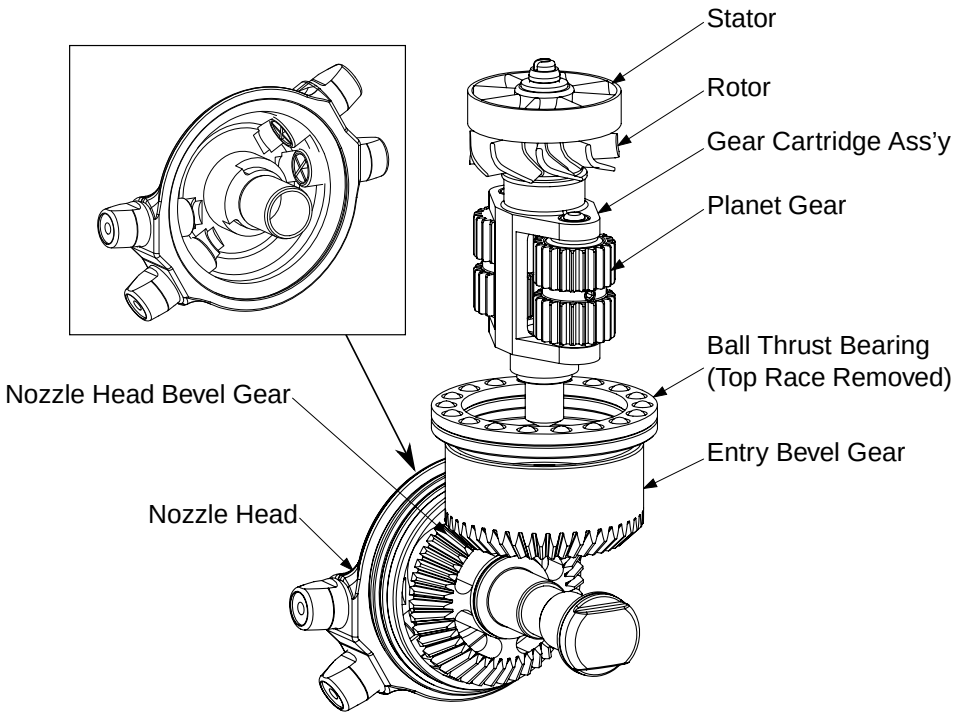

Figure 2: Orbitor 100 tank washing machine with housings removed.

Performance and Technical Data

Operating Conditions

Operating pressure range	3 bar to 10 bar	45 psi to 145 psi
Maximum pressure	12 bar	175 psi
Maximum operating temperature	95 °C	195 °F
Minimum ambient storage temperature	−40 °C	−40 °F
Maximum ambient storage temperature	140 °C	285 °F

Dimensions

Available inlet connections, female pipe thread	3/4 BSP (G) 1 BSP (G)	3/4 NPT 1 NPT
Length, not including nozzles	193 mm	7.6 in
Width, not including nozzles	76 mm	3.0 in
Height	76 mm	3.0 in
Minimum opening diameter, nozzles in any orientation	100 mm	4.0 in
Minimum opening diameter, nozzles vertically aligned	85 mm	3.35 in
Installed weight, approximate	2.5 kg	5.5 lb
Packed Dimensions		
Length	545 mm	21.5 in
Width	270 mm	10.6 in
Height	280 mm	11.0 in
Total gross weight	$<$ 4 kg	$<$ 9 lb

Cleaning Fluids

Orbitor 100 TWMs are capable of resisting most cleaning fluids provided:

- They contain no
  - Solid abrasive particles
  - Chemicals liable to attack the TWM construction materials. See materials list below.
- Temperatures specified in Operating Conditions are not exceeded

Approved cleaning fluids:

- Water at a temperature below 200 °F (below 95 °C)
- $<$ 5 % NaOH caustic soda solution
- Other cleaning fluids can be used with advice of BETE

Construction Materials

Component	Material
Nozzle head, nozzles and internal parts unless specified below	316L stainless steel
Body shell	Kolsterised 316L stainless steel
Gears	PEEK (PVDF or other materials available by special order)
Seals	PTFE, 10 % carbon filled
Seal seats	Ceramic coated
Bushings	PTFE, carbon filled
Ball bearings / race	Kolsterised 316 stainless steel Duplex 2205 steel (hardened)

Please note – Do not use any chemicals on the TWM while cleaning that might affect the integrity of the non-metallic component parts. If in doubt contact BETE for advice.

Performance Table

Tables 1 – 4 show total water flow, total jet length (effective cleaning may vary based on application), and typical cycle time for various nozzle configurations and sizes at different pressures.

Quick Wash or Rinse

The cycle times defined in the above table are for a full wash cycle.

Wash cycles can be repeated as many times as necessary. The TWM can also be stopped after one pattern generation for a quick rinse.

Installation, Mounting, and Washing Fluid Connection

Correct installation of an Orbitor 100 TWM is the responsibility of the tank owners, constructors, or installers. Mounting and connecting is a straightforward task for a competent fitter or technician.

BETE is happy to offer technical support and recommendations upon request but does not normally carry out installation work and cannot be responsible for ensuring correct installation practice or application.

TWM machine installation - key points:

- Machines will be positioned in the tank to permit the best cleaning jet coverage of walls, floor and tank cover.
- The cleaning pattern required and selection of flow and jet length depends on:
  - Tank dimensions.
  - Properties of the stored product residue.
  - Available flow and pressure.
- The axis of rotation of the spherical main body is along the axis of the inlet.
- The axis of rotation of the nozzle head is perpendicular to inlet axis — see Fig. 3).
- Machines will normally be mounted to the tank top cover and project down.

Table 1
Orbitor 100 Performance Information, US Units

Pressure	4 × ⌀3.0			4 × ⌀4.0			4 × ⌀5.0			4 × ⌀6.0		
	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time
psi	gpm	ft	min	gpm	ft	min	gpm	ft	min	gpm	ft	min
45	12.0	3.3	6.0	17.8	6.6	5.4	23.7	8.2	4.4	30.6	9.8	3.9
60	13.9	4.9	5.4	20.3	8.2	4.7	26.7	9.8	3.9	34.0	11.5	3.4
75	15.8	6.6	4.8	22.7	9.8	4.1	29.6	11.5	3.4	37.3	13.1	3.0
90	17.6	6.6	4.3	25.1	9.8	3.6	32.3	11.5	3.0	40.6	13.1	2.6
100	18.8	8.2	4.0	26.6	11.5	3.3	34.1	13.1	2.8	42.8	14.8	2.4
115	20.5	8.2	3.6	28.9	11.5	2.9	36.7	13.1	2.4	46.0	14.8	2.1
130	22.2	9.8	3.2	31.2	13.1	2.7	39.1	14.8	2.2	49.2	16.4	1.9
145	23.9	11.5	2.9	33.4	13.1	2.5	41.4	14.8	2.0	52.4	16.4	1.7

Table 2
Orbitor 100 HR Performance Information, US Units

Pressure	4 × ⌀3.0			4 × ⌀4.0			4 × ⌀5.0			4 × ⌀6.0		
	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time
psi	gpm	ft	min	gpm	ft	min	gpm	ft	min	gpm	ft	min
45	12.9	12.5	19.5	16.5	14.4	25.5	24.2	16.4	16.3	30.6	18.0	21.5
60	14.2	14.9	16.8	19.2	17.1	21.6	26.9	19.1	14.1	34.0	20.6	18.7
75	15.7	17.0	14.6	21.8	19.4	18.3	29.6	21.4	12.2	37.3	22.9	16.3
90	17.2	18.8	12.8	24.2	21.3	15.7	32.2	23.2	10.9	40.6	24.7	14.3
100	18.3	19.8	11.8	25.7	22.3	14.2	33.8	24.3	10.2	42.8	25.7	13.2
115	20.1	21.0	10.7	27.9	23.6	12.5	36.3	25.4	9.6	46.0	26.9	11.8
130	21.9	22.0	10.0	29.9	24.5	11.5	38.7	26.2	9.5	49.2	27.8	10.8
145	23.8	22.6	9.7	31.8	25.0	11.0	40.9	26.6	9.8	52.4	28.2	10.3

Table 3
Orbitor 100 Performance Information, SI Units

Pressure	4 × ⌀3.0			4 × ⌀4.0			4 × ⌀5.0			4 × ⌀6.0		
	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time
bar	L/min	m	min	L/min	m	min	L/min	m	min	L/min	m	min
3	45.0	1.0	6.0	66.7	2.0	5.5	88.3	2.5	4.5	115	3.0	4.0
4	51.7	1.5	5.5	75.0	2.5	4.8	100	3.0	4.0	127	3.5	3.5
5	58.3	2.0	5.0	85.0	3.0	4.3	110	3.5	3.5	138	4.0	3.0
6	65.0	2.0	4.4	93.3	3.0	3.8	120	3.5	3.0	152	4.0	2.7
7	71.7	2.5	4.0	102	3.5	3.3	130	4.0	2.8	163	4.5	2.4
8	78.3	2.5	3.5	110	3.5	2.9	140	4.0	2.5	175	4.5	2.1
9	85.0	3.0	3.1	118	4.0	2.6	148	4.5	2.1	187	5.0	1.8
10	90.0	3.5	3.0	127	4.0	2.5	157	4.5	2.0	198	5.0	1.8

Table 4
Orbitor 100 HR Performance Information, SI Units

Pressure	4 × ⌀3.0			4 × ⌀4.0			4 × ⌀5.0			4 × ⌀6.0		
	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time	Flow	Jet Length	Cycle Time
bar	L/min	m	min	L/min	m	min	L/min	m	min	L/min	m	min
3	48.3	3.7	20.0	61.7	4.3	26.0	90.0	4.9	17.0	115	5.4	22.0
4	53.3	4.5	17.0	71.7	5.1	22.0	102	5.7	14.0	127	6.2	19.0
5	57.5	5.1	14.5	80.0	5.8	19.0	110	6.4	12.0	138	6.9	16.5
6	64.2	5.6	13.0	90.0	6.4	16.0	120	7.0	11.0	152	7.4	14.5
7	70.0	6.1	12.0	98.0	6.8	14.0	128	7.4	10.5	163	7.9	13.0
8	76.7	6.4	10.8	107	7.2	12.5	138	7.8	10.0	175	8.2	12.0
9	83.3	6.7	10.0	113	7.5	11.5	147	8.0	9.5	187	8.5	11.0
10	90.0	6.9	9.5	120	7.6	11.0	155	8.1	9.5	198	8.6	10.0

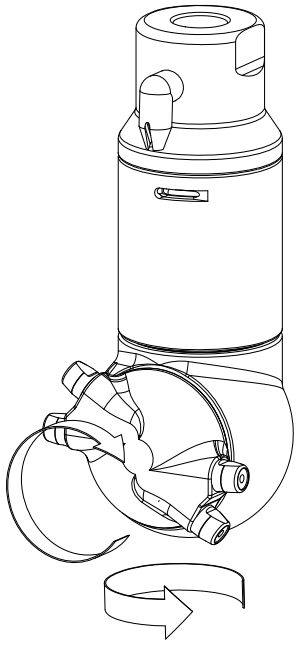

Figure 3: Rotation direction of nozzle head and body.

- Machines may also be inverted and project through the tank floor.
  - Please assume the vertical down orientation in following text.
- BETE or its agents will be pleased to offer application and installation advice and can produce cleaning diagrams (also known as shadow diagrams) if required (refer to the Installation Checklist provided in this document).

The inlet comprises a cylindrical housing with an internal (female) thread sized for alternative pipe thread systems. The standard internal threads are:

3/4 NPT	3/4 BSP (G)
1 NPT	1 BSP (G)

This threaded interface provides both fluid connection and structural machine mounting functions. It is recommended to install a coarse filter of 0.06 in (1.5 mm) minimum mesh in the supply line.

Installation Checklist

TWM Serial Number	
Location of TWM Installation	
Date	

Stage	Task	✓	Details	Name of Technician
Pre-Installation	Has a system level Hazard Analysis been conducted?			
	Is the cleaning fluid supply filtered?			
	Test and record cleaning fluid supply pressure.			
	Record here the normal cleaning fluid specification and temperature.			
Post-Installation	Check pipe tightness.			
	Check nozzle tightness.			
	Test electrical resistance between nozzle tips and installation pipe and tank structure.			
	Test electrical resistance of portable hoses.			
	Rinse the system with clean water.			
	Test for smooth operation and regular running speed.			

Mounting - Loads and Weights

Tank owners, constructors, or installers are responsible for the structural integrity of the TWM mounting. The installation specification and design should consider the following.

- Maximum static weight is 5.5 lb (2.5 kg, 24.5 N).
  - Weight of pipe work and fluids are additional.
- Single nozzle reaction forces can be up to 9 lb (40 N) depending on pressure and nozzle size.
  - Normally these forces are balanced by opposing nozzles.
- Structural strength and stiffness of the mounting must be sufficient.
  - The natural vibration frequency of the mounting must be many times the forcing frequency.
  - Masonry vessels are a particular concern and may require manufacture of large pipe flanges or structures to spread loads.
- Pipe work systems must be designed to prevent water hammer effects.
  - Forces produced by water hammer can far exceed normal reaction loads and can damage the TWM and supply pipework.
- Installations must be designed by a competent engineer or other qualified individual.

Fixed Installations

Fixed machines are used for applications where the stored media or process will not be affected by the presence of a permanent machine. This type of installation requires the least operator intervention and the lowest component costs. In practice, specification differences between fixed and portable machines are few.

The fluid coupling and machine mounting is specific to each tank installation. Normally, fixed machines are mounted on rigid pipes, often flange mounted to the tank roof or floor. BETE can supply suitable flanged and weld prepared pipe assemblies. Pipe length depends on tank size and required jet pattern. Short flanged pipes form a compact unit ideal for top down washing.

Longer pipes, also known as Drop Pipes or Free Standing Units (FSU's), will require additional strengthening to prevent fatigue fracture due to vibration. Long pipe installations are designed in collaboration with the customer and often include steadying cable rigs or tie bars.

A machine fixed in a dirty environment might experience the nozzles becoming blocked by the contaminant which will affect the machines performance. If this condition is likely to occur, inspection and cleaning of the nozzles prior to use is advised.

Ensure all fixed installations are clear from any obstructions that might prevent the nozzle head from rotating.

Portable Installations

Portable machines are only needed while cleaning and are moved out the way during normal operation. The equipment is stowed when not in use. Portable machines are most often used with a large bore flexible hose with pipe threaded end couplings. Flexible hose mounting allows the cleaning machine to be guided into different positions in the tank with manually controlled cables. The TWM operator can thereby concentrate the cleaning action in particularly stubborn areas.

Operation Instructions

Conditions for Safe Working

- Only competent and qualified persons should carry out and check installation work.
- Follow the installation instructions in this manual.
- Complete the Installation Checklist printed in this manual.
  - Record installation details.
  - Store manuals with check lists appropriately in an accessible location.
- Use Orbitor 100 TWMs within the technical parameters defined in the Operating Conditions.
- Ensure that personnel cannot touch hot TWM surfaces or be hit by high power cleaning fluid jets.

  - Beware of hazardous cleaning fluids.

- Maintain Orbitor 100 TWMs in accordance with the instructions provided in this Product Manual.
  - Check nozzle tightness regularly.

General Operating Instructions

- Always
  - Rinse with clean water after operation.
  - Ensure that any tank openings are completely sealed off and can withstand the full force of the striking jet.
  - Allow the machine to gradually reach its operating pressure to avoid water hammer effects. A sudden spike could cause parts to wear prematurely or fail.
  - Store and dispose of cleaning fluids in accordance with current rules and directives.
- Never
  - Back drive the TWM by manually rotating nozzle heads.
  - Drive the TWM with steam or with a liquid at a temperature above 200 °F (95 °C).

Maintenance Manual

The Orbitor 100 TWM is designed to allow for field maintenance. These machines may also be returned to BETE for maintenance if desired. To ensure correct operation of the machine, it is mandatory that all spare parts be supplied by BETE.

Once maintenance has been carried out by either party the installation test procedure must be conducted on reinstallation. A new Installation Checklist is required to be completed and maintained.

Schedule

In order to prevent machine failures, routine maintenance should be carried out at a maximum of

500 hours of operation

Maintenance should include cleaning all internal parts and assessing the wear of seals, gears, bearing and bushes.

- Any fine solid particles left inside the machine will increase wear considerably.
- Orbitor 100 TWM requires no lubrication.
  - The Orbitor 100 TWM is lubricated by the spray media during operation.

Attention

- Before maintenance can be carried out, it is important the machine is not contaminated with chemicals that could be hazardous.
- Always
  - Use the tools stated throughout this manual. Special tools for Orbitor 100 maintenance can be purchased from BETE.
  - Read the technical data thoroughly before carrying out any work on this machine.
  - Record any wear found and check for smooth operation of the machine after maintenance.

  - After any maintenance is carried out flush and sterilize (if appropriate) the machine before further use.

- Never
  - Service the Orbitor 100 TWM while hot.
- Any parts found to be unserviceable should be replaced before further use. If the tank being cleaned contains a combustible liquid or vapor with a risk of ignition or explosion, re-check that the Orbitor 100 TWM is properly grounded after maintenance.

Recommended Tools List

- 1.5 mm Allen wrench
- 14 mm open end wrench
- 10 mm open end wrench
- Strap wrench
- Screwdriver
- 2.5 mm pin punch
- Light hammer
- Vise
- Set of 2 x Side Plate Tools (Part No. DM03116 for the set)
- Spider Tool (Part No. DM03114)
- Loctite 2700
- Torque wrench (suitable for applying 27 ft · lb [37 N · m])
- Fly-press or soft-jawed vise

Disassembly Operations

Nozzle Head and Retaining Head Bolt – Disassembly

Please reference Fig. 4 on page 23.

1. Holding the Orbitor 100 by hand, place 14 mm wrench onto the retaining head bolt, (DM03038).
2. Use tool (DM03117) to hold the nozzle head, and use 14 mm wrench to unscrew the retaining head bolt.

   Please note – The assembly has 180° of lost motion
3. The nozzle head (DM03030) should now be free to lift off.
4. Slide out the retaining head bolt (DM03038) from the main body and remove the nozzle head bevel gear (DM03037).

   Please note – Be careful not to lose any seals, spacers, or bushings.
5. Check seal (DM03039) in nozzle head for wear, if excessively worn remove by cutting free.
6. There should be a ceramic-coated seal insert (DM03032) left in the main body. This should be replaced if the ceramic coating is showing signs of wear (i.e. chipped or grooved from contact with mating seal). For replacement instructions, please see Seal Insert Removal on page 30.
7. Two bushings (one of DM03028 and one of DM03029) and thrust bearing (DM03009) should still be inside the main body and should be carefully assessed for signs of wear.
8. One bushing (DM03028) should still be inside the bevel gear and should be carefully assessed for signs of wear.
9. If necessary, remove nozzles from head and inspect the stream straighteners for any foreign bodies; remove as needed.
10. Both bushings (DM03028 and DM03029) in main head can now be removed.

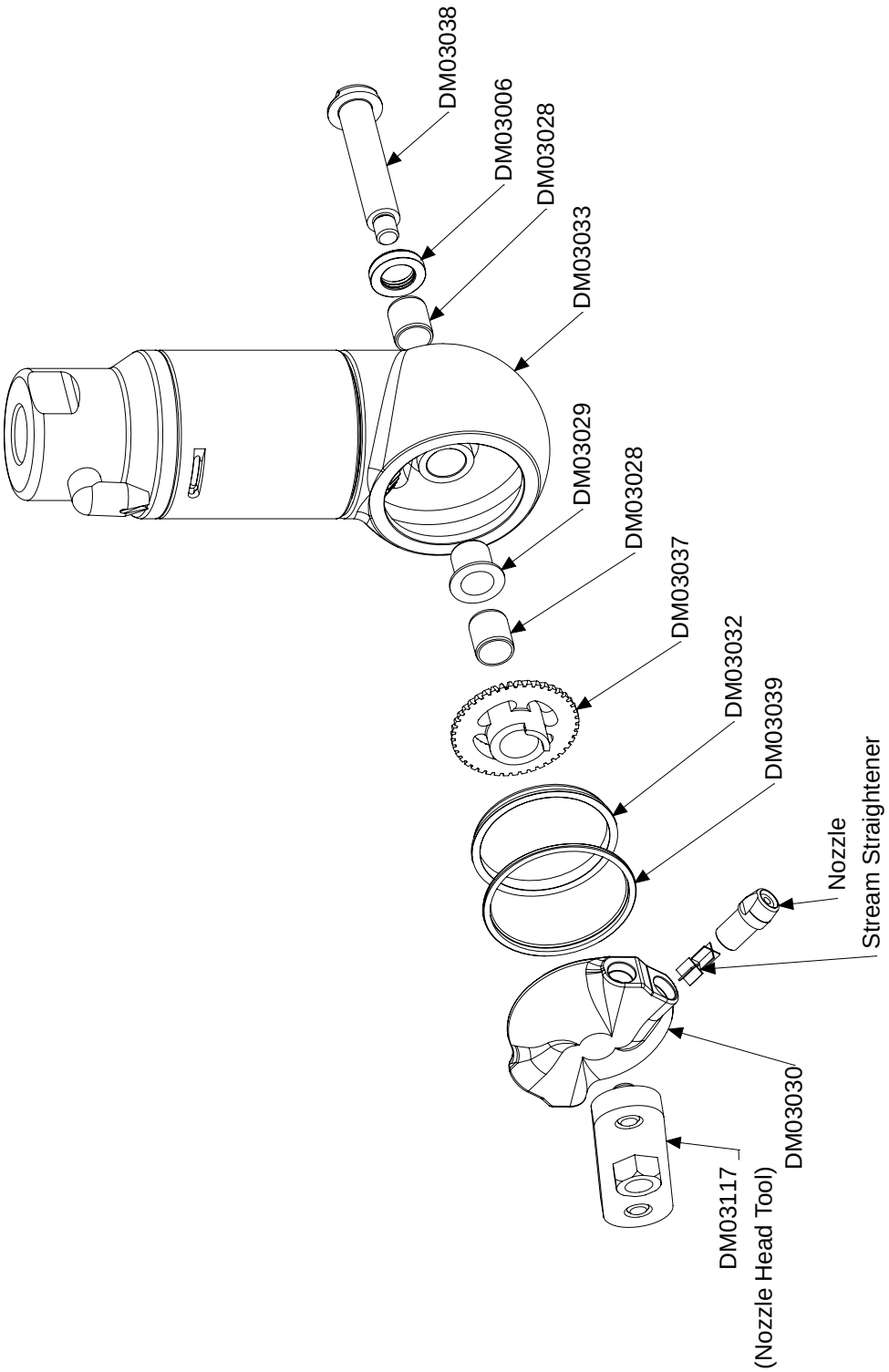

Figure 4: Nozzle head disassembly.

Body Shell and Inlet Casing – Disassembly

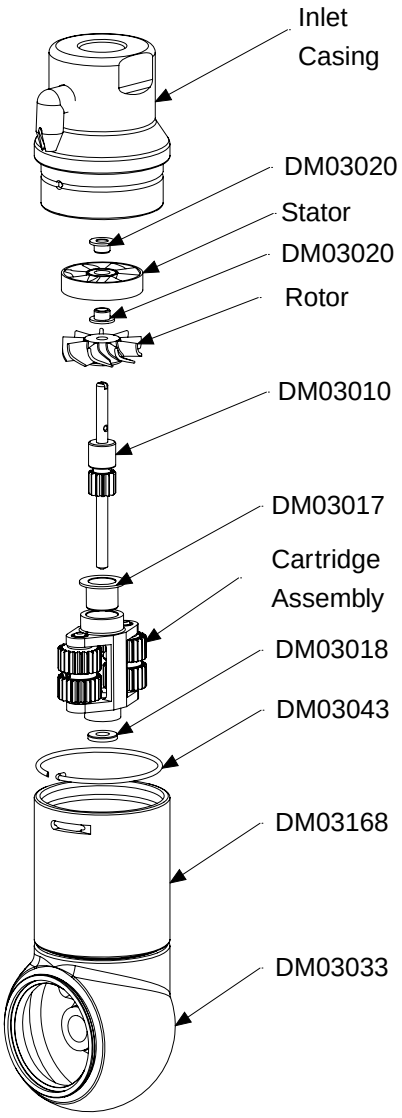

Figure 5: Body shell and inlet casing disassembly.

1. Hold machine by inlet casing* at the bottom and turn the body shell (DM03168) counter-clockwise by hand or alternatively with a strap wrench if tight.

   ***Please note – To find part number for an inlet casing refer to Parts List on page 35.**

2. This should allow spring clip (DM03043) to extrude from slot. Unhook clip using a screwdriver.

3. Lift shell (DM03168) up from the inlet casing.

   Please note – You should be left with the cartridge and rotor subassemblies in inlet.

4. Pull out cartridge and rotor subassemblies and inspect for wear.

5. Remove the stator bushings (DM03020) if necessary.

Rotor Shaft Subassembly – Disassembly

Rotor can be removed from shaft if necessary by unscrewing hollow set screw (DM03099).

Please note – For specific rotor part numbers refer to Parts List on page 35 as these vary depending on machine.

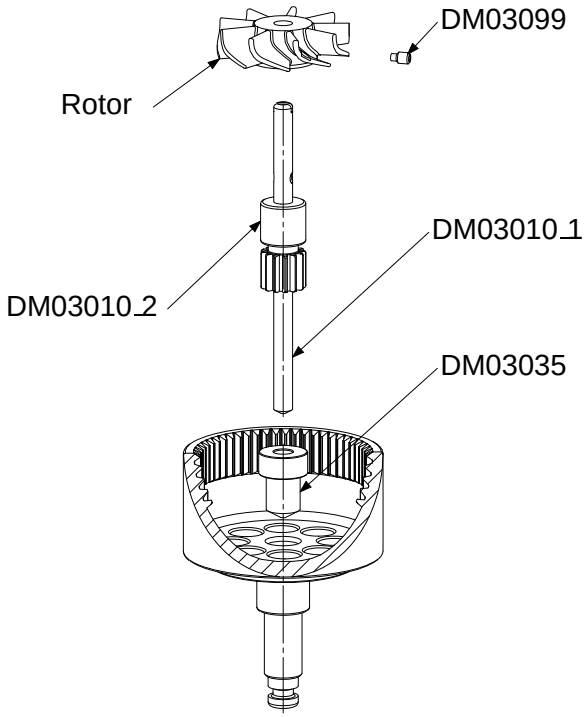

Figure 6: Rotor shaft subassembly.

Gear Cartridge Subassembly – Disassembly

1. Unscrew hollow set screws (DM03021) in both planet shafts; this should allow removal of both shafts (DM03022).
2. Remove both planet gears, aligned (DM03019) and offset (DM03040); check for wear.
3. Check cartridge bushing (DM03017), shaft bushings (DM03020) and support washer (DM03018), inspect for wear.

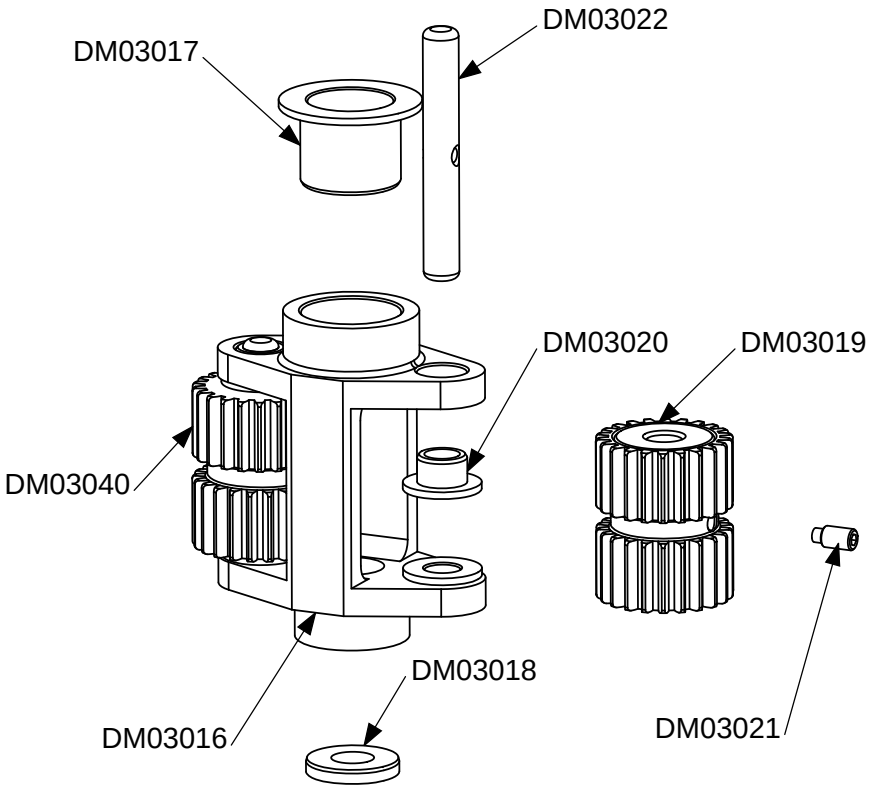

Figure 7: Cartridge subassembly.

Main Body and Body Shell – Disassembly

Please note – Before attempting to remove body shell (DM03168) from main body (DM03033), ensure you remove retaining pin.

1. Remove retaining pin (DM03048) from main body (DM03033) using 2.5 mm pin punch. (DM03115)

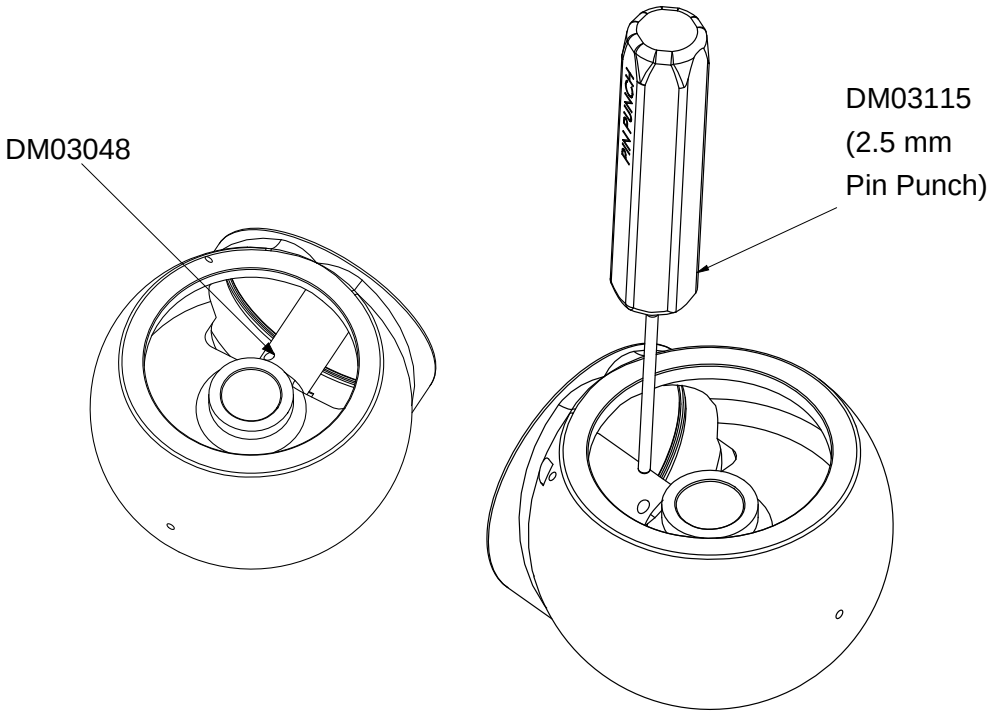

Figure 8: Removal of pin that prevents separation of main body, body shell, and spider components.

2. Install the two side plate tools (DM03116) to faces of body (for protection of the ceramic-coated seals) and place in vise.
3. Using spider tool (DM03114), loosen spider (DM03034) from main body.

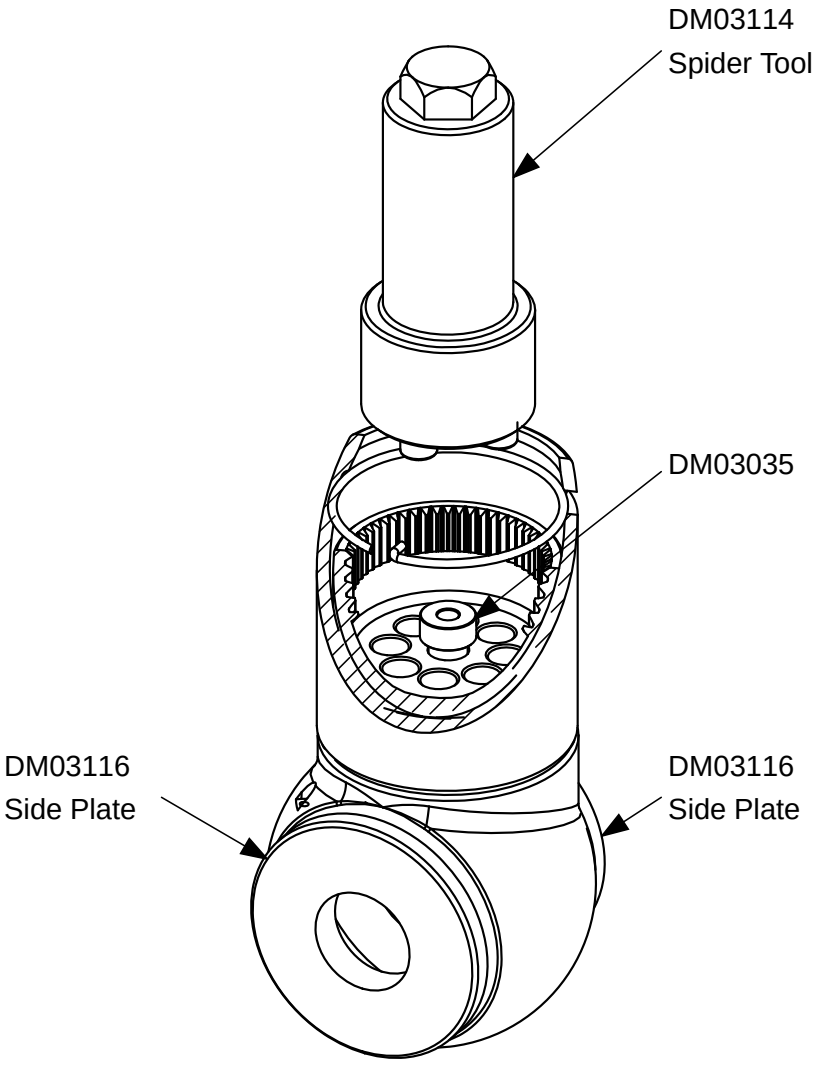

Figure 9: Spider tool.

4. Lift body shell (DM03168) and spider (DM03034) from main body (DM03033) and separate internal components.

   Please note – The 18 bearing balls (DM03013) are no longer captured after the spider (DM03034) is removed from the body shell (DM03168). At this stage the bearing balls are loose and may easily roll out of the body shell. Use caution!

Inspection

- Inspect all seals, bearings, and bushings for signs of wear and replace if necessary.
- Check all gear teeth for wear:
  - Nozzle head bevel gear (DM03037)
  - Sun gear (DM03010_2)
  - Cartridge gears (DM03019 and DM03040)
  - Spider (DM03034)
  - Bevel gear at base of body shell (DM03168)
- Check ceramic-coated seal inserts (DM03032) on body shell (DM03168) and main body (DM03033).

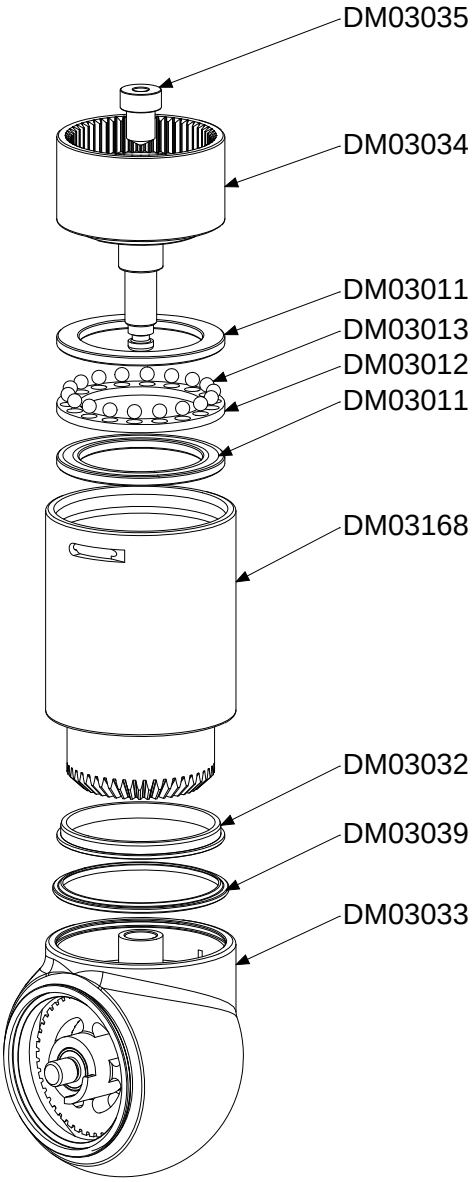

Figure 10: Main body assembly.

Seal Insert Removal

1. To remove ceramic-coated seal inserts (DM03032), clamp main body (DM03033) or body shell (DM03168) into a soft jaw vise.

   Please note – Ensure soft jaw vise does not damage or distort any parts.

2. Place a tool with a very fine, sharp edge at the interface between the seal insert and the main body. Gently tap the tool so that the edge slides between the seal insert (DM03032) and main body (DM03033)/body shell (DM03168).

3. Slowly lever the edge until slight separation of faces; repeat process in different 4 equally spaced locations to ensure equal removal of seal.

Reassembly Operations

Main Body and Body Shell – Reassembly

1. If the ceramic-coated seal inserts (DM03032) were removed, reinstall by pushing them back into main body (DM03033) and body shell (DM03168) using Loctite 2700.
2. Reassemble bearing assembly to spider (DM03034) and insert into body shell (DM03168).
3. Pick up the main body (DM03033), place the side plate tools (DM03116) on the sides of main body, and place in vise.

   Please note – Use of the side plate tools is to protect the ceramic-coated seal inserts. Not using the side plate tools may cause damage to the seal inserts.
4. Insert seal (DM03039) to top of main body, if removed.
5. Locate spider using spider tool and screw assembly to main body through body shell (DM03168) using Loctite 2700 on thread of spider shaft.
6. Using torque wrench on head of spider tool (DM03114), tighten spider (DM03034) to 27 ft · lb (37 N · m).
7. Remove whole assembly from vise and remove side plate tools (DM03116).
8. Install a new 2.5 mm pin (DM03048) in hole inside main body using 2.5 mm pin punch (DM03115).

Gear Cartridge Subassembly - Reassembly

1. Replace cartridge bushing (DM03017), shaft bushings (DM03020), and support washer (DM03018) if removed.
2. Slide both gears into place and insert shafts aligning holes in gears and shafts for hollow set screw.
3. Insert set screws (DM03021) and tighten.

Rotor Shaft Subassembly – Reassembly

Rotor can be replaced to shaft if necessary by sliding onto shaft and reinserting hollow set screw (DM03099).

Please note – For rotor part number refer to Parts List on page 35 as these may vary between Orbitor 100 models.

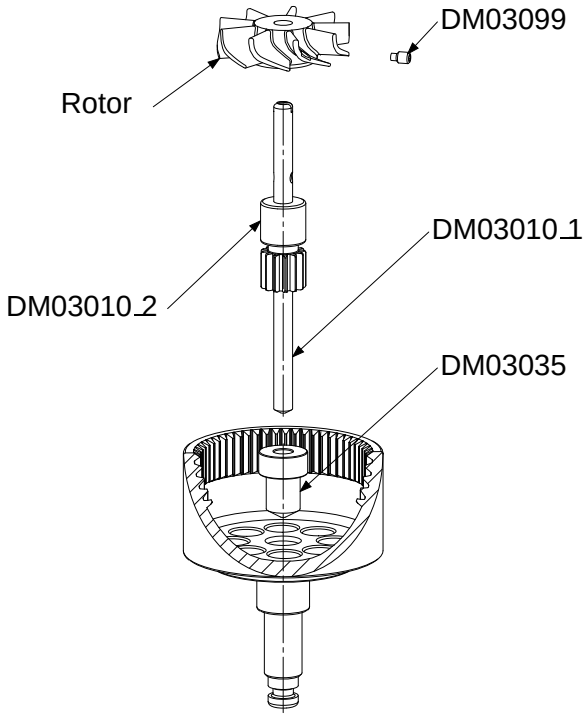

Figure 11: Rotor shaft subassembly.

Body Shell and Inlet Casing – Reassembly

1. Hold machine with body shell opening oriented upward and insert gear cartridge subassembly.
2. Insert rotor shaft subassembly, guiding rotor into cartridge.

   Please note – Check for smooth operation by spinning the turbine shaft by hand.
3. Replace the stator bushing (DM03025) in stator inside the inlet casing, if removed.
4. Hold machine with body shell opening oriented upward and slide the inlet casing into body shell (DM03168).

   Please note – Ensure hole in inlet casing is aligned with slot in the body shell (DM03168).
5. Fit the spring clip (DM03043) through slot in the body shell (DM03168) into the hole in the inlet casing and turn slightly to locate in its position.
6. Rotate machine vertically so that inlet opening is oriented downward and hold inlet connection in vise, located on flats.
7. Turn body shell (DM03168) 360° clockwise to fit spring clip completely in inlet casing.

   Please note – Use new spring clip (DM03043) if necessary.

   Please note – Tighten with strap wrench if necessary.

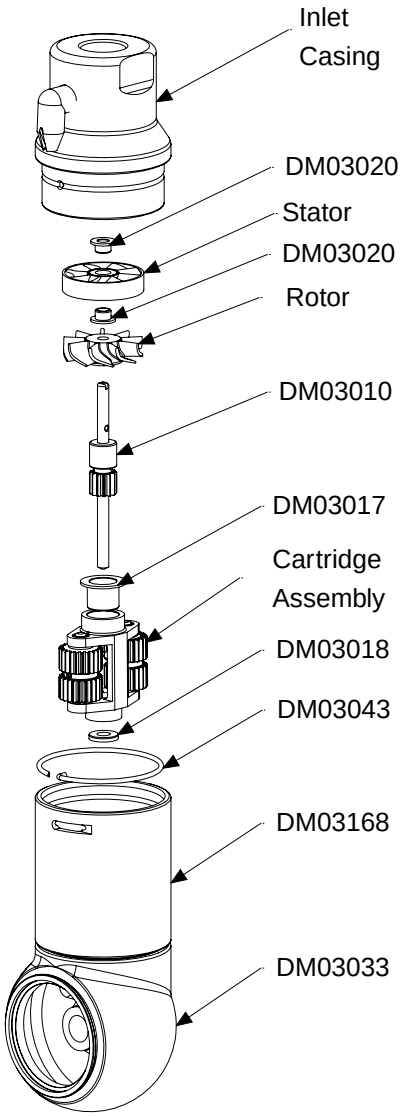

Figure 12: Body shell and inlet casing assembly.

Nozzle Head and Retaining Head Bolt – Reassembly

1. Hold machine in a vise by the inlet casing flats, and replace new bushings (DM03029 and DM03028), thrust bearing (DM03009), and seal (DM03039), if necessary.
2. Slide retaining head bolt (DM03038) into place.
3. Replace bushing (DM03028) if necessary. Install new bushing into bevel gear (DM03037) and slide over retaining head bolt (DM03038).
4. If nozzles were removed, ensure stream straighteners are in place and replace nozzles to nozzle head. Use Loctite 2700 on the nozzle thread taking care not get any Loctite on the shoulder face as this may impair conductivity between the nozzle and the nozzle head.
5. If removed, replace seal into groove of nozzle head.
6. Using the nozzle head tool to secure the nozzle head, use the 14 mm wrench to tighten the retaining head bolt to 27 ft · lb (37 N · m).

Parts List (see Fig. 13)

Part No.	Quantity	Description
DM03009	1	Thrust bearing assembly
DM03010_1	1	Rotor shaft
DM03010_2	1	Sun gear
DM03010_3	1	Sun gear pin
DM03011	2	Thrust bearing race
DM03012	1	Thrust bearing cage
DM03013	18	Ball bearing, ⌀4.5 mm
DM03016	1	Cartridge
DM03017	1	Cartridge bushing
DM03018	1	Support washer
DM03019	1	Planet gear, aligned
DM03020	6	Gears and stator bushing
DM03021	3	M3 dog point set screw
DM03022	2	Gear shaft
DM03023	1	Rotor, full
DM03024	1	Stator, full
DM03025	1	Stator bushing
DM03028	2	Bevel gear bushing
DM03029	1	Nozzle head bushing
DM03030	1	Nozzle head, 4-way
DM03032	2	Ceramic-coated seal
DM03033	1	Main body
DM03034	1	Spider
DM03035	1	Spider bushing
DM03037	1	Nozzle head bevel gear
DM03038	1	Retaining head bolt
DM03039	2	Face seal, PTFE
DM03040	1	Planet gear, offset
DM03042	1	Down wash spigot
DM03043	1	Spring clip
DM03048	1	Dowel pin
DM03099	1	M3 x 8 dog point set screw
DM03168	1	Body shell

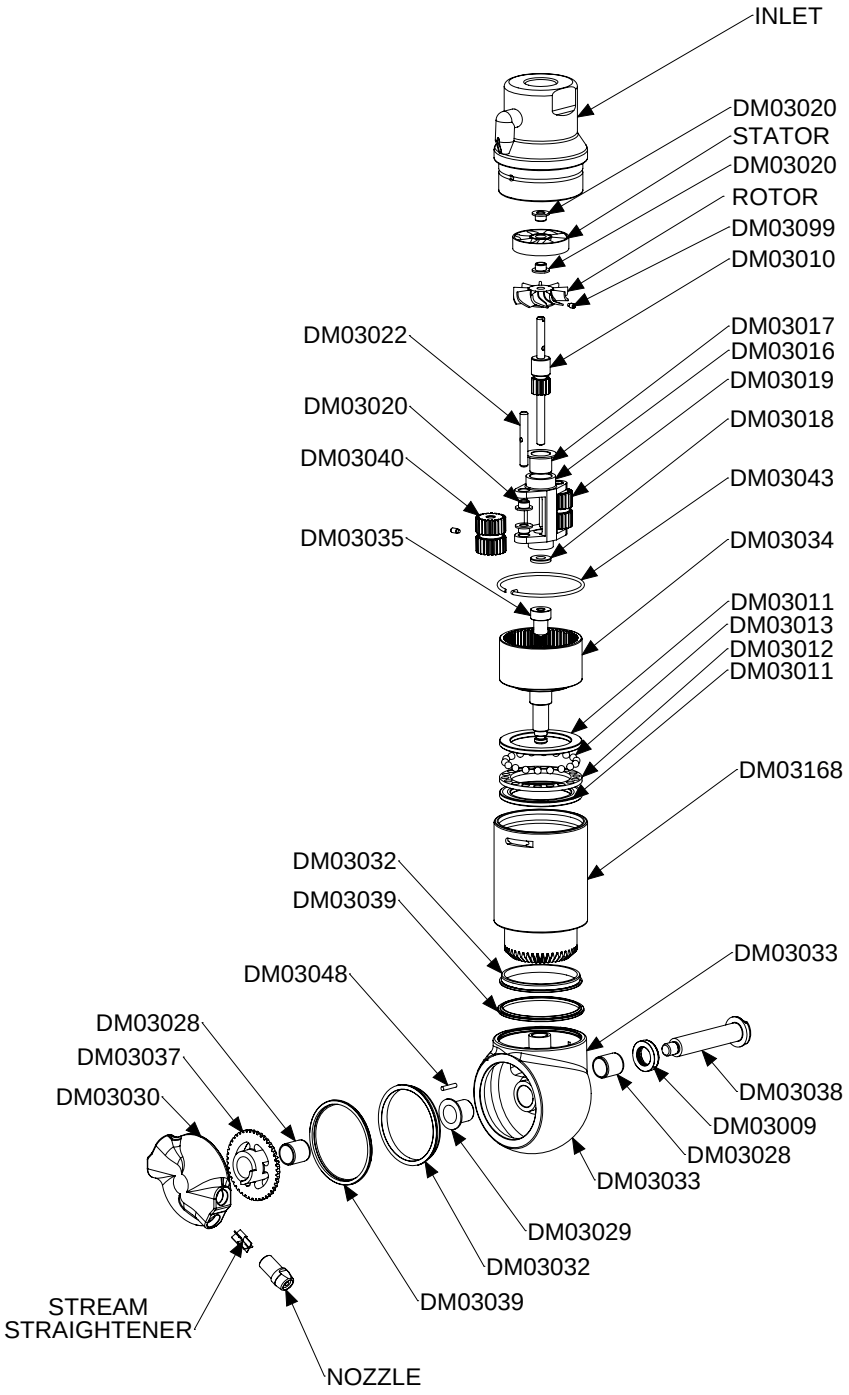

Figure 13: Exploded view of the Orbitor

Interchangeable Parts

Part No.	Description
Rotors	
DM03023	Full rotor
DM03150	5° positive rotor
DM03151	15° positive rotor
DM03152	10° negative rotor
Stators	
DM03024	Full stator
DM03004	2 Blade stator
DM03025	4 Blade stator
Nozzles x4	
DM03044	3.0 mm diameter
DM03045	4.0 mm diameter
DM03046	5.0 mm diameter
DM03047	6.0 mm diameter
Inlet Casing	
DM03119	3/4” NPT female
DM03118	3/4” BSP (G) female
DM03120	1” NPT female
DM03026	1” BSP (G) female

Service Tool Kit

Part No. 186090

Each kit includes:

Part No.	Qty	Description
DM03114	1	Spider tool
DM03115	1	2.5 mm pin punch
DM03116	1	Side plate tool, set of 2
DM03117	1	Nozzle head tool

Each part number in the tool kit can be purchased separately.

Rebuild Kits

Three rebuild kits are available depending on the level of service your Orbitor 100 has experienced. A tabular list of the items supplied in each kit is shown on the following page. This list is also shown graphically on the subsequent page in Fig. 14.

Kit D, Part No. 186087
The basic kit that provides replacement of the seals.

Kit E, Part No. 186088
The standard kit that provides replacement of the seals and the bushings.

Kit F, Part No. 186089
The complete kit that provides replacement of the seals, bushings, and ceramic-coated seal inserts.

Orbitor 100 Rebuild Kit Contents

Part No.	Qty	Description	Material	Kit D	Kit E	Kit F
DM03009	1	Thrust bearing assembly	Stainless Steel			✓
DM03017	1	Cartridge bushing	10% carbon filled PTFE		✓	✓
DM03020	6	Bushings (gear & stator)	10% carbon filled PTFE		✓	✓
DM03028	2	Bevel gear bushing	10% carbon filled PTFE		✓	✓
DM03029	1	Nozzle head bushing	10% carbon filled PTFE		✓	✓
DM03032	2	Seal insert	Stainless Steel Tech 28 Ceramic Coated			✓
DM03035	1	Spider bushing	10% carbon filled PTFE		✓	✓
DM03039	2	Face seal	ACoflon 212CF (10% carbon filled PTFE)	✓	✓	✓
DM03043	1	Spring clip	17-7 PH Stainless Steel (Werkstoff 1.4568)	✓	✓	✓
DM03048	1	Dowel pin, ⌀2.5 mm	316L Stainless Steel	✓	✓	✓

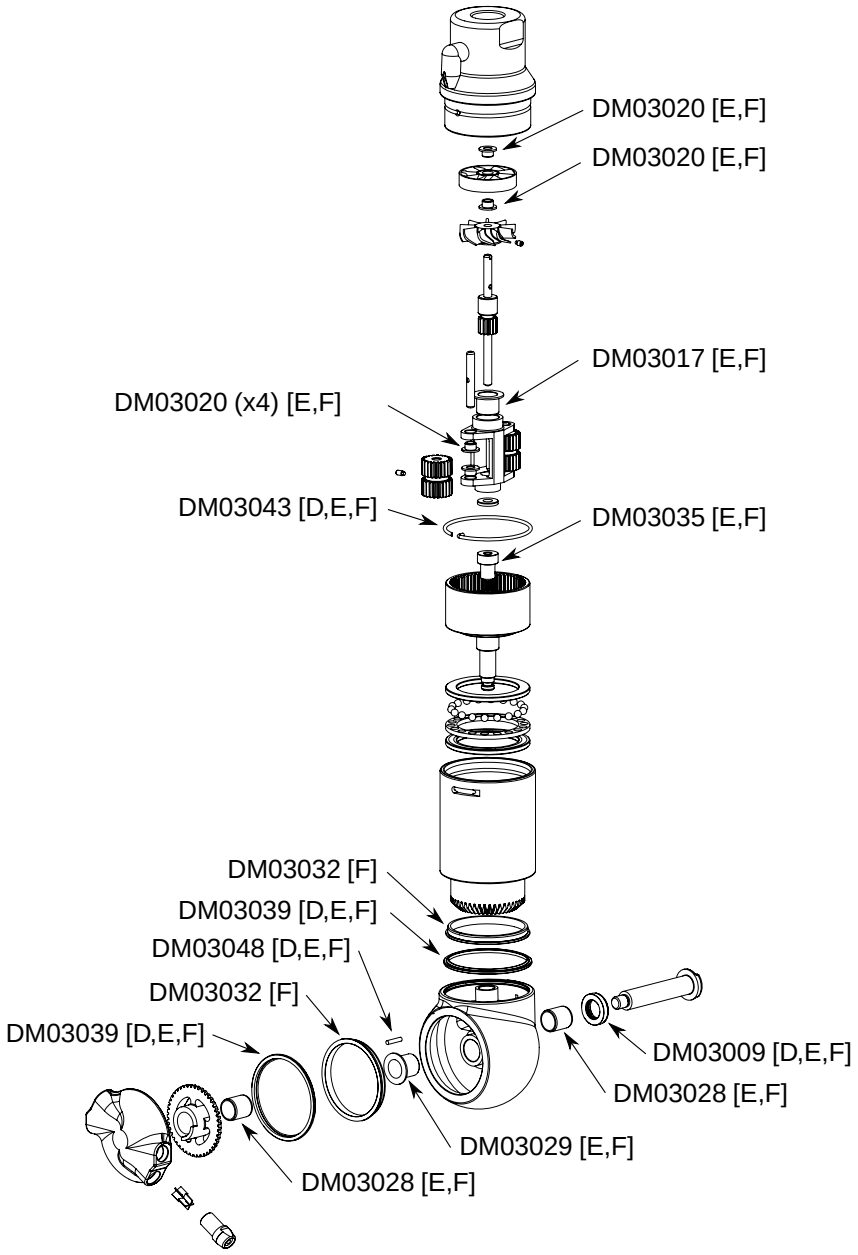

Figure 14: Rebuild kit components. Letters in brackets are the kits in which that component is included.