Atlas Copco Gas and Process

تاسیس ۱۳۶۲
جهان کمپرسور
خدمات معتبر
Jahan Compressor
Since 1983

Instruction Manual

Type	**:**	**ETG 450 MS-2**
Codeword	**:**	**Midrex-Angul**
Order No.	**:**	**562 37 238**
Machine No.	**:**	**15-3832**
Built in	**:**	**2011**
Purchaser's Ref. No.	**:**	

Atlas Copco Energas GmbH
Schlehenweg 15, 50999 Köln
Germany

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This manual meets the requirements for instructions specified by the EC-machinery directive and is valid for CE as well as non-CE labelled machines.

The legally binding copy of the turbomachinery manual shall be the printed version which was delivered by Atlas Copco GAP as contractually stipulated.

Any unauthorized use or copying of the contents or any part thereof is prohibited.

This applies in particular to trademarks, model denominations, part numbers and drawings.

The owner of the turbomachinery unit shall have the right to make copies of this manual for his own use. He is, however, advised to order additional copies at the competent Atlas Copco representation or the Atlas Copco Parts & Service Center against invoice to make sure that the latest edition is available on the job.

All users of this manual are requested to advise Atlas Copco GAP of each and every insufficiency they detected, in particular those concerning product safety.

Structure of manual

The turbomachinery manuals are an integral part of their scope of supply. They contain information on characteristic features and handling of the turbomachinery unit to ensure that the unit is ready for operation any time and must be filed for further use.

The manuals, although comprehensive, are not in a position to replace thorough and in-deep training of your personnel. The manuals consist of the following chapters that are checked here:

		IM	EM	OM	MM	
A	Basic safety precautions	X	X			
B	Transport, storage and preservation	X	X			
C	Erection	X	X			
	First commissioning	X				
D	Operating instructions	X				
	Possible faults, causes and corrections	X				
E	Plant description	X				
F	Technical data *)	X	X			
G	Maintenance	X				
H	Annex *)	X	X			
	Technical documentation of sub-suppliers *)	X	X			

*) Content may be different in each manual

IM: Instruction Manual;
EM: Erection Manual;
OM: Operation Manual;
MM: Maintenance Manual;



Prior to commencing any work on the turbomachinery unit, the manuals must be read by all those who are supposed to handle, assemble, operate, service or repair the turbomachinery unit.

Compliance with the instructions for operation, maintenance and repair shall be mandatory.



If a separate erection manual is supplied, it will not be updated after erection is completed! All relevant information from the erection manual are included and updated in the instruction manual or the maintenance manual.

Document number

The document number (Document-Id) is composed of the type of document (EM, OM, MM, ...) and the order number seperated by an underscore:

<document type>_<order number>

Example: IM_56037564

File name

Every chapter of a manual is a seperate file with the file name composed of:

<document type>_<order number>_<section identifier>_<language as per ISO 639-1>_<revision identifier>.<file type>

Example: EM_53037664_T_en_3_0.doc

or: OM_53138113_B_it_1_2.pdf

Revision identifier

The revision is indicated with figures in two stages - seperated by an underscore (e.g. 1_3)

- 1. stage: changes in content
- 2. stage: language and spelling changes (the change affects one language only)

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Service addresses

You will find the service center that is responsible for you on our homepage below "Aftermarket/Service presences worldwide" or "Customer Contacts".

Here you can access all service addresses available globally .

**Used abbreviation in this manual:*

GAP	for Atlas Copco Gas and Process Division
AC	Atlas Copco in general

Modification control of manual

The turbomachinery manuals should always be up-dated. Modifications might become necessary whenever

- new experience gathered during commissioning call for changes or supplements.
- turbomachinery was subjected to basic changes that became necessary on account of experience made with comparable machinery.
- customer feedback is considered.

Please help us to up-date the manuals by keeping us informed about any improvements and/or substantial changes, e.g. of operating parameters. After revision, we will replace the modified pages of the manual by the updated version and return them to you.

Modification, supplements			Issued		Checked
Revision	Chapter	Description/page	on	by	
0_0	--	--	2011_09_12	Sauermann	Genzel

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Addresses

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A 1 Dangerous nature of the turbo-machine

This turbomachinery unit has been designed and manufactured in accordance with the most current recognised safety rules and regulations. Still, its application might entail danger of bodily injury to users or third parties and/or damage to other material assets.

The turbomachinery unit must only be operated when it is in good working condition. It is imperative that operating personnel adhere to all operating instructions and danger warnings. In particular, all interference that might impair safety must be eliminated at once.

Atlas Copco shall honour its obligations deriving from the guarantee conditions stipulated in the purchase agreement only if all rules and instructions contained in the machinery instruction manual have been adhered to.

For turbomachine emission data refer to the chapter "Technical data".

A 2 Specific safety precautions, used pictographs and signs

The turbomachinery manuals contain the following terms, pictographs or signs which are used for especially important indications.

The use and layout of pictographs, warnings and terms are established on the basis of ANSI, DIN EN and EC Machinery Directive.



Indicates that death or severe personal injury may occur.

CAUTION Special information on the prevention of material damage.



Special notes and instructions for safe operation.



Read manufacturer’s instruction manual.



Environmental friendly disposal of packing materials, detergents and fluids required for operation.

Danger signs attached to turbomachinery plants must not be removed or painted. Signs must be kept clean and left at readily visible places.

The following warning and obligatory signs are described below. These signs may be attached to the turbomachinery plants. Adherence to these signs is mandatory, as non-compliance may lead to bodily injuries.

Sign	**Potential danger or unavoidable residual risk**
	Part/component is subjected to internal pressure, danger by pressure impact
	Danger of body parts being drawn or pulled into the machine, pinched or squashed off
	Machine can be started automatically or remote controlled from control room
	Danger by high temperatures
	Danger by low temperatures
	Danger by electric voltage
	Ear protection required
	Ear protection and helmet required
	Danger by ignorance of operating instructions

A 3 Proper and due application

This turbomachine has been designed to be operated at the operating conditions specified in chapter "Technical data".

For safe operation of the turbomachinery plant, it is imperative to comply with specified performance data to ensure that the existing limit values are not exceeded. This applies in particular to used fluids, operating pressures and temperatures, and mass flows and speeds.

Operation of turbomachinery outside the range of specified performance data is allowed only after consulting with our service department Exceeding any operational limits can lead to incorrect loading of turbomachine or plant parts.

In addition, it is absolutely imperative to protect the turbomachinery plant against hazardous environmental impacts (dust, sand, corrosive agents) to rule out any increased wear and tear.

It is of special importance to keep the gases that enter the turbomachinery unit free of:

- liquids
- dust, sand
- solid particles

(or at most to limit them as specified), as their presence will lead to extensive damage when they enter the impeller.

Unauthorised modifications, in particular those that will impair machine safety, are prohibited. The plant user shall be liable for any damage resulting from such action.

The following rule applies in EC-member states:

- The CE Declaration of Conformity issued for the turbomachine must be available.
- If the user modifies essential parts of the plant he was handed over (e.g. driver) he shall be obliged to update the Certificate of Conformity.
- According to the ATEX Directive 99/92/EC, the plant user has to prepare an operator’s handbook for turbomachines used in potentially explosive atmospheres.

Unauthorised modification of the PLC software programs without prior permission by Atlas Copco is prohibited.

Proper and due application also means compliance with the instructions for inspections and maintenance. Intervals for recurring maintenance, inspections and revisions must be adhered to.

A 4 Selection and qualification of personnel

Turbomachinery is dangerous, unless it is installed, operated, maintained and repaired by authorised, qualified and trained staff.

We recommend scheduling our competent Atlas Copco personnel to carry out such activities as installation, commissioning and revisions.

CAUTION Unqualified staff shall be prohibited to work on the machine.

Any work that has to be performed on the turbomachinery unit in the course of the guarantee period must always be carried out by Atlas Copco personnel. Exceptions in emergencies must be authorised by Atlas Copco.

If this requirement is not met, Atlas Copco is entitled to withdraw from a part or all of its contractual/statutory obligations. In particular, the Atlas Copco guarantee liability for defects shall become void, if and when these defects were caused by:

- improper handling
- the use of unsuited operating auxiliaries
- insufficient or incorrect installation
- improper conduct of piping

Work on electrical equipment of the turbomachinery plant must only be carried out by expert staff in keeping with the rules of the art.

A 5 Think safety

Adherence to any national, local or plant-specific regulations shall be mandatory. This shall also apply to the accident prevention rules.

The complete set of manuals, or at least the operating instructions, must always be on hand at the site of application.

The staff in charge of working on or with the turbomachinery unit shall read and fully understand the relevant chapters of the machine manuals, especially the safety precautions, prior to performing any work. This applies in particular to staff that is working only temporarily on the machine in question, i.e. maintenance and repair staff.

Staff shall be trained in safety-related matters by the plant safety supervisor on the basis of the machinery manuals**.** The plant safety supervisor is obligated to thoroughly review the requirements included in the manuals, the local conditions prevailing at the plant and the safety instructions issued specifically for the plant.

The plant user has to provide the safety relevant chapters of the manuals in the language of the country of erection.

It is strongly recommended that these safety training courses should be carried out in regular intervals.

The turbomachinery unit must only be operated, if it is in good working condition.

Maintenance work on the machine must only be carried out when the machine is not in operation and is de-pressurized. Motors and other driving equipment must be protected against restart.

Protective devices must only be removed when the turbomachinery unit is not in operation. Prior to re-commissioning the unit, it must be verified that these devices were re-installed.

You are obligated to carry out a functional test in regular intervals as specified in the maintenance plan.

A 6 National regulations, laws and rules

You are requested to adhere to the laws, regulations and rules that are applicable to your plant.

Adherence to the following regulations, laws and rules along with the EC - regulations applicable to the operation of the plant supplied by Atlas Copco is mandatory:

- Regulations for the prevention of accidents
- Other safety rules issued by trade associations
- Industrial Code, this includes e.g. technical instructions for silencing equipment
- Regulation governing hazardous materials and the regulation for working materials

The following regulations must also be adhered to, even if there is no direct danger of bodily injury:

- Technical instructions to keep the air clean
- Regulation for materials harmful to water
- Regulation for used oil
- Regulation for waste disposal
- Transport of special and non-recyclable waste as per law governing dangerous goods

A 7 Safety instructions about pressure equipment

Warnings attached to pressure equipment must not be removed or hidden by paint.

Pressure equipment must be installed, operated and serviced to manufacturer’s instructions.



May lead to severe injuries or death.

Pressure equipment and associated safety devices must not be manipulated.

Subsequent welding is absolutely prohibited.

The official inspection intervals applicable to pressurized components (pressure equipment) are to be observed. The national laws, rules and regulations valid in the country of erection, and the inspection intervals in the manufacturer's documentation are also to be observed.

A 8 Provisions for explosion protection

Warnings attached to explosion protection equipment and devices must not be removed or hidden by paint.

Explosion protection equipment and devices must be installed, operated and serviced to manufacturer's instructions.



May lead to severe injuries or death.

Devices and equipment used for explosion protection must not be manipulated.

Prior to commissioning and during operation it must be absolutely ascertained that potential sources of ignition cannot be generated in the explosive atmosphere, such as:

- mechanically generated sparks
- electrostatic strokes
- hot surfaces
- chemical reactions
- flames and hot gas
- arcs and lightning
- ionizing radiation
- electromagnetic waves
- optical radiation



Observe the official inspection intervals applicable to explosion protection equipment and devices. Also observe the national laws, rules and regulations valid in your country, refer also to manufacturer's documentation.

The plant user is responsible for erecting sufficient danger area signs.



Increased Fire Hazard due to explosive process gases (e.g. O_2, H_2, CO, …)

Solvents and lubricants that are not approved for these process gases must not be used.

After assembly, maintenance or cleaning of the turbomachine, and prior to commissioning, all plant parts and accessories are to be purged with clean, dry gas. This gas must be of a type that does not react with the process gas. Therefore, it has to be ensured that all dust, rust, foreign particles, liquids and all contamination incompatible with the process gas have been removed.

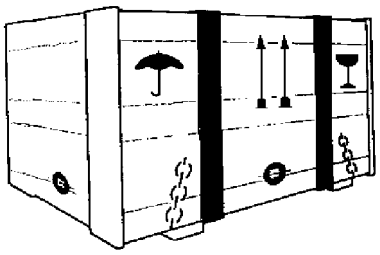
Measuring instruments approved for this process gas must be used only!

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B 1 Safety instructions for transport and storage

You are requested to pay attention to the marks attached to the consignments.

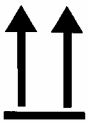


Danger: suspended load/falling parts

May lead to severe injuries.

- Use only approved hoisting equipment and cranes of sufficient capacity. For information on weights refer to the foundation and layout plan, or information on packing.
- Employ special auxiliary equipment, e.g. traverses, loading joists, if specified.
- Use only undamaged ropes and chains.
- Protect the edges whenever hoisting chains or ropes are placed over edges of packing or machinery.
- Lifting eyelets are not always designed to receive the total weight. Pay attention to the information contained on their stickers.
- Secure parts against shifting during transport/handling.
- Observe the shift in center of gravity during transport.
- Refrain from standing below suspended loads.

The consignment markings are described as follows:


This side up


Fragile


Keep dry


Keep cool


Do not use hooks


Center of gravity


Sling here


Blade of handtruck here


Do not destroy barrier

For the following items, arrangements between AC and the customer must be stipulated:

- Transport of the turbomachine to the site
- Storage and storage condition of materials and plant parts on site
- Transport of materials and plant parts on site, inclusive of the means of transport for unloading and erection

A site meeting shall be held in conjunction with inspection of the site and shall deal with the following main points:

- Approach routes leading up to the foundation of the turbomachine
- Heights and widths of passage on all access and approach routes
- Space required
- Availability of electric power, water, compressed air supplies
- First - Aid station
- Lifting and hoisting equipment available (shop cranes, mobile cranes)

B 2 Status on arrival

The turbomachinery unit and its accessories have been subjected to the tests as stipulated by contract. They have been packed for the specified method of transport to avoid any damage. They are packed and preserved prior to shipment as specified in the purchase agreement.

All nozzles and openings of the unit have been plugged up to protect it against impurities. They may only be opened if it is no longer possible for dirt and foreign particles to enter the unit.

Please make sure that the consignment’s packing material is intact on its arrival at your site, as it is supposed to protect the consignment during transport, e.g. against entry of water.

Whenever packing is damaged, open the packages in the presence of the truck driver or delivery agent and have them confirm the damage. Do not use the goods!

Whenever packing is intact, but the goods are nevertheless damaged, report the damage without delay.

Please check the consignment for completeness and damage against the dispatch note.

Also inform the competent representation of Atlas Copco GAP or directly:

Atlas Copco Parts & Service Center

CAUTION For reasons of safety, the turbomachinery will be delivered without any oil filling.

B 2.1 Identifikation of delivered parts

Every delivery includes:

- a packing list
- an assembly list

Packing list The packing list includes a list of all packaging units (Collis), belonging to a delivery.

Atlas Copco

Packing list

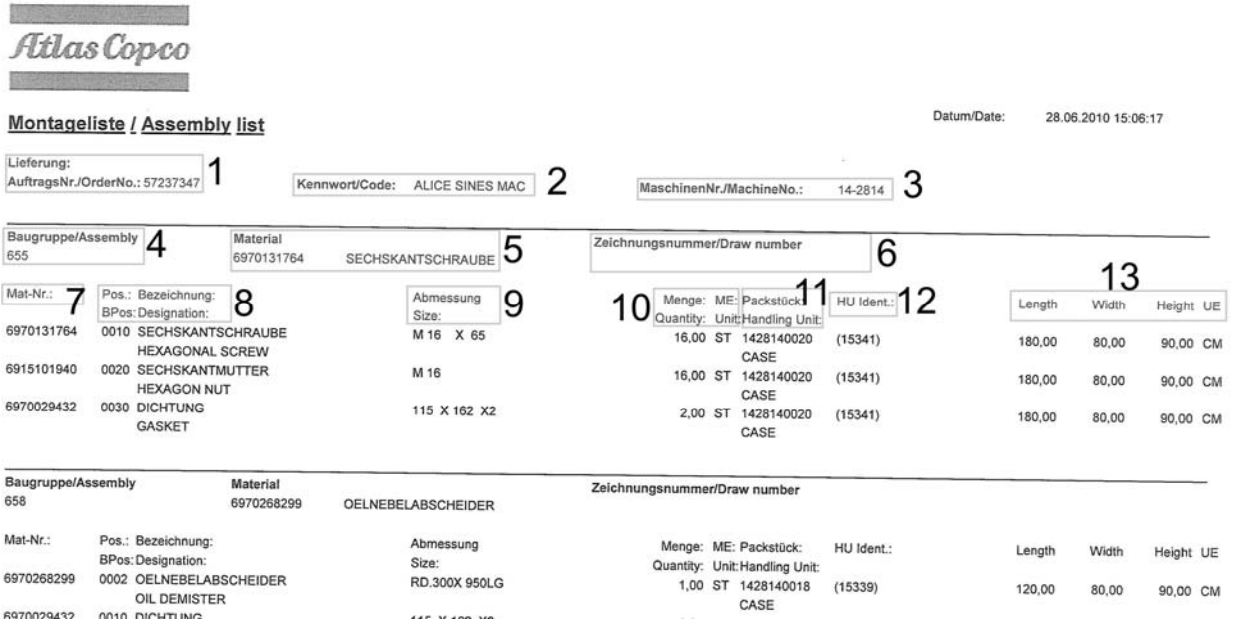
Date: 28.06.2010 14:29:07

Delivery:	20044096	1									
OrderNo.:	57237347	2	Code:	ALICE SINES MAC	3			MachineNo.:	14-2814	4	
Package	int.HU	ext.HU	Length	Width	Height	Unit Gr.	Weight	Net Weight	Unit		Colli 20
CASE	1428140020	(15341)	180,0	80,0	90,0	CM	608,0	550,0	KG		10
5	6	7	8				9				

Material-No. 11	Description DE 12	Description EN 13	Size 14	Quantity 15	Unit 16	Import Codenummer 17
	1420000000 CE PLATE			1,00	PC	
	1420030416 GUIDE RODS			2,00	PC	
	1420152926 CHECK VALVE			1,00	PC	
800001238	ROUND SEALING RING	ROUND SEALING RING	O-RING TEILFUGE H VERD	1,00	M	
	1420032217 SCR CAP HEX			4,00	PC	
6970200784	VIBRACON ELEMENT	VIBRACON ELEMENT	140/ 62	4,00	PC	
6970131713	HEXAGONAL SCREW	HEXAGONAL SCREW	M 30 X 130	4,00	PC	
6970137860	DISC/WASHER/PULLEY	DISC/WASHER/PULLEY	31	4,00	PC	
6970136025	HEXAGONAL SCREW	HEXAGONAL SCREW	M 30 X 100	8,00	PC	
6970131764	HEXAGONAL SCREW	HEXAGONAL SCREW	M 16 X 65	16,00	PC	
6915101940	HEXAGON NUT	HEXAGON NUT	M 16	16,00	PC	
6970029432	GASKET	GASKET	115 X 162 X2	2,00	PC	
6970029432	GASKET	GASKET	115 X 162 X2	1,00	PC	
6915101940	HEXAGON NUT	HEXAGON NUT	M 16	8,00	PC	
6970131764	HEXAGONAL SCREW	HEXAGONAL SCREW	M 16 X 65	8,00	PC	

1 [Delivery:] Delivery number
2 [OrderNo:] AC Order number
3 [Code:] AC Code
4 [MachineNo:] Machine number
5 [Package] Type of packaging
6 [int.HU] Internal AC number of handling unit (HU), consisting of the machine number and consecutive numbering.
7 [ext.HU] External number of handling unit (Customer's number or AC's internal number)
8 Dimensions ([Length] Length, [Width] Width, [Height] Height, [UnitGr.] Unit)
9 Weight ([Weight] Gross, [Net Weight] Net, [Unit] Unit)
10 [Colli] Short number of the handling unit
11 [Material-No.] AC Material number of the single piece.
12 [Description DE] Description German
13 [Description EN] Description English
14 [Size] Size
15 [Quantity] Quantity
16 [Unit] Unit
- PC Piece
- M Meter
17 [Import Codenummer] Import Code

Assembly list In the assembly list the parts delivered are ordered by assembly. The complete assembly list will be delivered with the last delivery. The assembly list is attached to the largest part of a packaging unit, if packed seaworthy on the outside of the case.



Montageliste / Assembly list

Datum/Date: 28.06.2010 15:06:17

Lieferung: AuftragsNr./OrderNo.: 57237347 1 | Kennwort/Code: ALICE SINES MAC 2 | MaschinenNr./MachineNo.: 14-2814 3

Baugruppe/Assembly 4: 655 | Material 5: 6970131764 SECHSKANTSCHRAUBE | Zeichnungsnummer/Draw number 6

Mat-Nr.: 7	Pos.: BPos:	Bezeichnung: Designation: 8	Abmessung Size: 9	Menge: Quantity: 10	ME: Unit:	Packstück: Handling Unit: 11	HU Ident.: 12	Length 13	Width	Height	UE
6970131764	0010	SECHSKANTSCHRAUBE HEXAGONAL SCREW	M 16 X 65	16,00	ST	1428140020 CASE	(15341)	180,00	80,00	90,00	CM
6915101940	0020	SECHSKANTMUTTER HEXAGON NUT	M 16	16,00	ST	1428140020 CASE	(15341)	180,00	80,00	90,00	CM
6970029432	0030	DICHTUNG GASKET	115 X 162 X2	2,00	ST	1428140020 CASE	(15341)	180,00	80,00	90,00	CM

Baugruppe/Assembly: 658 | Material: 6970268299 OELNEBELABSCHEIDER | Zeichnungsnummer/Draw number

Mat-Nr.:	Pos.: BPos:	Bezeichnung: Designation:	Abmessung Size:	Menge: Quantity:	ME: Unit:	Packstück: Handling Unit:	HU Ident.:	Length	Width	Height	UE
6970268299	0002	OELNEBELABSCHEIDER OIL DEMISTER	RD.300X 950LG	1,00	ST	1428140018 CASE	(15339)	120,00	80,00	90,00	CM

1 [AuftragsNr./OrderNo.:] AC Order number

2 [Kennwort/Code:] AC Code

3 [MaschinenNr./MachineNo.:] Machine number

4 [Baugruppe/Assembly] Assembly number (refer to Bassembly structure in Annex H3)

5 [Material] AC Material number and name of assembly

6 [Zeichnungsnummer/Draw number] Drawing number, if there are drawings for the assembly.

7 [Mat-Nr.:] AC Material number of the parts

8 [Pos.: | BPos:] Position number and [Bezeichnung: | Designation:] Designation of the parts

9 [Abmessung | Size:] Size

10 [Menge: |Quantity:] Quantity and [ME: | Unit:] Unit
- SA Set (Satz)
- ST Piece (Stück)
- M Meter

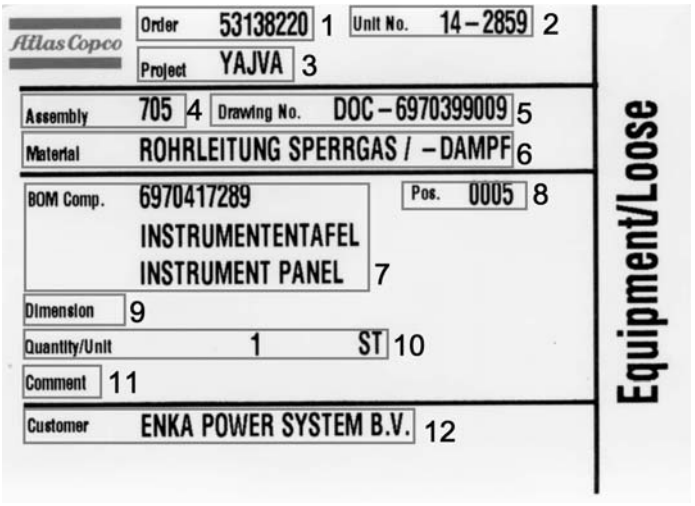
11 [Packstück: | Handling Unit:] Internal AC number of handling unit and type of packaging the parts are packed in

12 [HU Ident.:] External number of handling unit (optional) (Customer's number or AC's internal number)

13 [Length] Length, [Width] Width, [Height] Height, [UE] Unit of handling unit

Identification of loose parts

Every loose part carries a label including detailed information consistent with the packing list. Unit number and drawing number can be identical.



1 [Order] AC Order number
2 [Unit No.] Machine number
3 [Project] AC Code
4 [Assembly] Assembly number (refer to Assembly Structure in Annex H3)
5 [Drawing No.] Drawing number, if there is a drawing for the assembly.
6 [Material.] Name of assembly
7 [BOM Comp.] AC Material number (*) and designation of the part (German/English)
(*) or EXT + Position°number, in piping this refers the position number in the piping drawing (depending on the terms of delivery)
8 [Pos.] Position number
9 [Dimension] Dimension
10 [Quantity/Unit] Quantity and Unit
- SA Set°(Satz)
- ST Piece (Stück)
- M Meter
11 [Comment] Commentary
12 [Customer] Customer

B 3 Instructions for storage

Do not store machinery or their components without packing or without preservation in corrosive atmospheres, i.e. humid or saliferous air, etc.

CAUTION Compliance with these instructions for storage is mandatory.

Atlas Copco shall not be liable for damage by corrosion that was incurred by non-compliance with these instructions.



Danger: falling parts

May lead to severe injuries.

- Comply with instructions for load capacity of shelves and ceilings when storing parts
- Do not stack heavy parts

B 3.1 Storage of disassembled turbomachinery units

The unit has been factory-tested using an oil as per Atlas Copco Works Standard.

When longer storage periods of the disassembled plant or its single parts are inevitable, observe the following notes:

- As a rule, the turbomachine and its accessories and spare parts must be tarped during road or air transport. Even while stored, the consignment should be kept in its original packing, tarped and well aerated.
- Store the consignment in its normal position, free of distortion and well supported on solid ground.
- Protect the consignment against vermin.
- When consignments are stored outdoors, make sure that the tarpaulin does not have direct contact to the machine parts to ascertain proper air circulation. All parts must be protected from moisture from below.

If these conditions have been met and the packing has remained unopened and undamaged, the following storage periods are feasible:

Long-term packing

- Moderate climate, unopened PE-foil packing

  Maximum storage period: 9 months

- Tropical climate, unopened and undamaged packing of welded Al-compound foil

  Maximum storage period: 24 months

If a machine should be stored at ambient temperatures down to -20 °C (-4 °F) and a storage period up to 24 months the following must be considered:

- The machine is packed and delivered in a seaworthy package with alum earth as drying agent (shrink-wraped with ALU/PE compound foil and transported in a wooden transport box).
- The machine must be stored inhouse (heating is not mandatory).

- The ALU/PE compound foil is equipped with moisture indicators, indicating the moisture level inside the package in steps of 20 %, 40 %, 60 %, 80 % and 100 %.
- The mositure indicators must be checked weekly. At a moisture level of 40 % (the corresponding indicator changes the colour from blue to red) the package must be opened and the drying agent must be replaced. Afterwards, the package must be appropriately sealed by authorized personal. It is imperative that the ambient air is completely removed from the inside of the packaging.
- The packaging of the machine must be checked weekly to avoid any corrosion during the storage period. When the packaging is damaged in such a way that air humidity can enter the packaging, the machine must be repacked.
- The sight openings for the mositure indicators are clearly marked on transport box. If any repacking has to be done, consider that the moisture indicators of the packaging must be placed at their specific locations.



After 2 years of storage, the transport box and the ALU/PE compound foil must be opened and the drying agent must be replaced at the latest.

CAUTION Machines without special packing must be preserved directly after arrival at the site (see chapter "Preservation and protection against corrosion".

CAUTION It might be possible that bags containing desiccant were placed in the gas side of turbomachinery.

The number of bags that were used is indicated on caution signs. It is imperative to remove these bags prior to commissioning the machine.

Upon termination of the storage periods specified herein, the status of the parts must be checked. If required, they must again be preserved. Inform the Atlas Copco Service department immediately.

CAUTION If the customer requires extended storage beyond the listed periods, it is the responsibility of the customer to inform the Atlas Copco service department.

We recommended that the equipment is stored indoors in a clean, dry area. If stored outdoors, it is the responsibility of the customer to tarp the equipment to prevent water moisture damage and to inspect periodically for signs of corrosion or damage.

Pressure vessels filled with nitrogen

Pressure vessels or other parts of the plant filled with nitrogen are marked by the following yellow sign:



Achtung: 0,3 bar(g) Stickstoff

Attention: 0.3 bar(g) nitrogen

Attention: 0,3 bar(g) d'azote

When vessels have been preserved by means of a nitrogen filling, you must check pressure of N_2 filling in regular intervals. If it has dropped, refill.

B 3.2 Storage of electrical machines

Electrical machines must be stored in a clean and well-aerated storage location. This location should be kept at a constant temperature and be free of vibration. Protect the electrical machines against moisture, rodents and vermin.



If manufacturer's instructions do not contain sufficient information on methods of preservation and associated storage periods, contact the manufacturer.

B 3.3 Storage of elastomer seals (O-rings or similar)

The presence of oxygen, ozone, heat, humidity, solvents, etc. may have a considerable impact on the service life of elastomers. For this reason, proper storage of elastomer materials is imperative.

Elastomer seals should be packed in boxes or in paper-lined PE foils impervious to light. They should be stored in cool, dry, dust-free and moderately aerated rooms at an air humidity of approx. 65 % and at air temperature between +40 °C and -10 °C (104 °F and 14 °F).

B 4 Preservation and protection against corrosion

Preservation during installation

If the turbo machine is installed outdoors, we recommend the construction of a temporary protective canopy during set-up (tent or similar).

In case of short interruptions, i.e., over a weekend, it is enough just to cover the turbo machine with a tarpaulin.

Additionally, we recommend the use of a warm air heating if the ambient temperature is ≤ 5 °C (41 °F).

If installation is interrupted for any reason, precautions must be taken to ensure that the plant remains free of corrosion. The machinery must also be protected from corrosion once installation is completed, and for the duration prior to commissioning. We recommend sealing of all system openings and flushing of the whole machine (process gas system, seal gas system, oilsystem) with dry instrument air or nitrogen. The pressure has to be monitored continuously and be between 0.3 bar(g) [4.4 psi(g)] and 0.5 bar(g) [7.3 psi(g)].

If the oil system cannot be flushed with dry instrument air or nitrogen, it must be commissioned provisionally and operated once a day for at least 30 minutes (refer to chapter "Standstill operation").

B 5 Instructions for lifting



Danger due to suspended loads/falling parts.

The safety instructions at the beginning of the chapter have to be followed.

CAUTION During lifting and transport particular attention has to be paid to machine parts that protrude past the base frame

Lifting with a crane

Machines or machine parts (base frame, valve frame, cooler etc.) have to be kept horizontal when lifting.

Only the eyelets and lifting points provided may be used. Chains and ropes have to be led in such a way that no lines, cables or instruments are damaged.

If necessary additional chain hoists are to be used, or a traverse or wire rope slings with spreader bars.



Lifting with a forklift

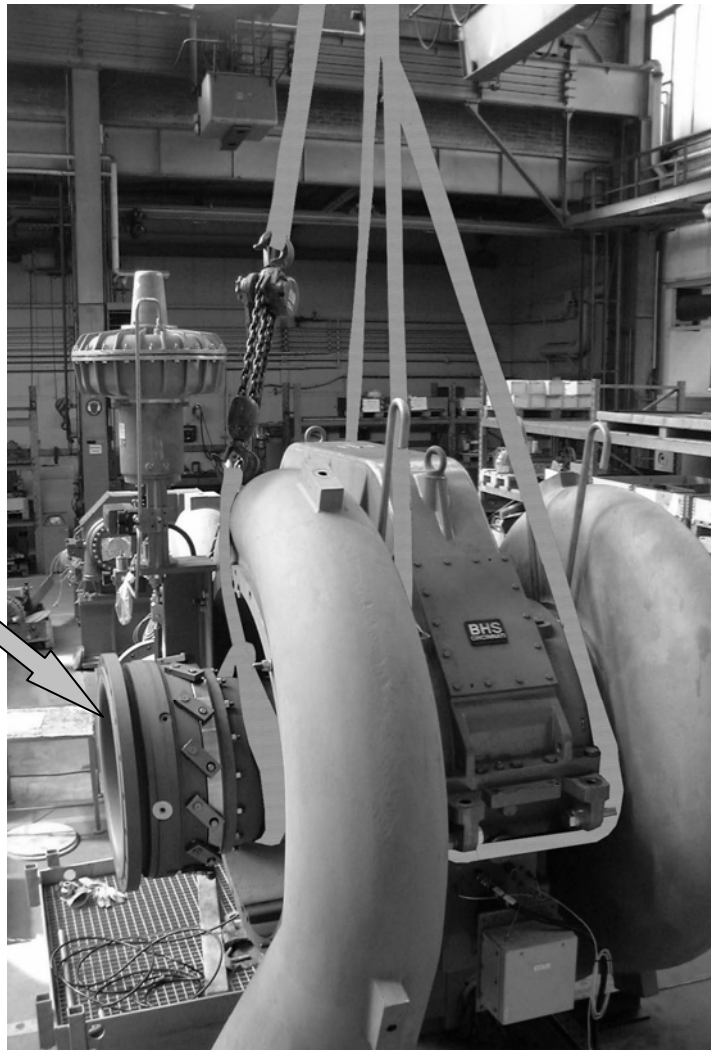
Machines or machine parts may only be lifted with a forklift at the specific points which are indicated. The forks have to be long enough to protrude out the other end.

Weights

Information about lifting points and weights can be obtained in the foundation and layout plans as well as in the manufacturer's specifications in the appendix.

The ropes must be attached and secured beneath the lowest split line. See the picture of a similar machine below.

The chain pull must be fixed on the suction casing using an additional sling.



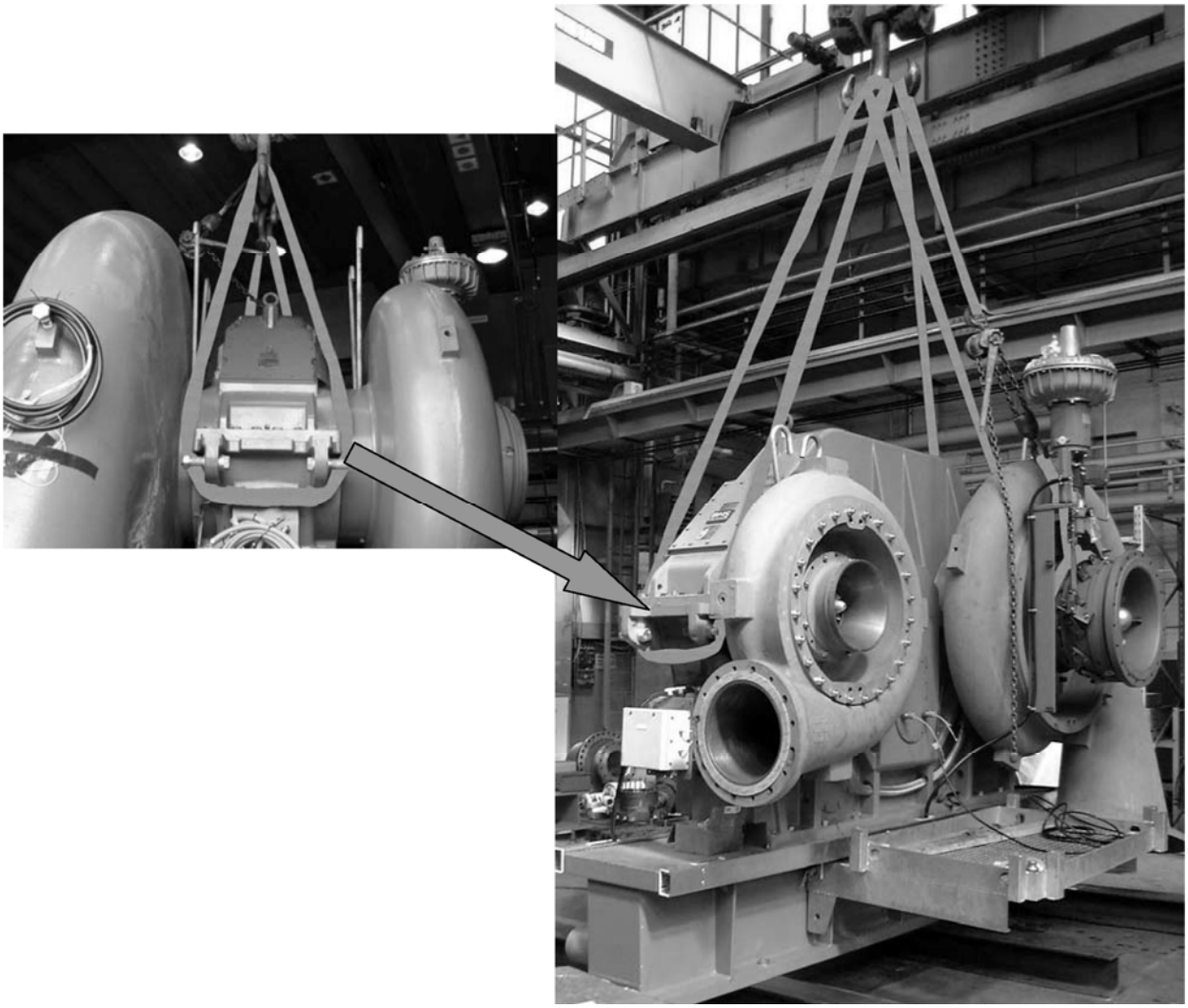


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C 1 Safety precautions



Danger by holes in concrete ceilings

May lead to severe injuries.

- Cordon off the erection area to make sure that persons cannot fall through these holes.



Danger: detergents and solvents

May lead to skin injuries, acid burns and other severe injuries

- Use only approved detergents and solvents.
- The use of easily inflammable solvents such as benzene, kerosene, naphtha or mineral spirit is prohibited. This applies also to fire-distinguishing liquids such as R12B1. We recommend that you refrain from employing any refrigerants, i.e. fluorinated hydrocarbons.
- Make sure to wear personal protective equipment such as safety goggles, rubber gloves, aprons and, if need be, breathing equipment.
- Make sure to vent closed rooms thoroughly when working with such detergents and solvents.



After use, all detergents and solvents are to be collected in closed containers for proper disposal. Ensure adherence to the warning signs on the containers which give information on which agents may be collected in the individual containers.



Danger by breathing residues when welding, soldering and grinding.

May lead to injuries and sickness.

- Provide sufficient fresh air during welding, soldering and grinding.



Danger of explosion

May lead to severe or lethal injuries.

- Only use spark-free special tools in hazardous areas.
- Smoking and open flame are expressly prohibited.
- Welding must only be performed if this is approved by the fire warnings issued by the customer.

CAUTION The machine must be protected against corrosive atmosphere, especially during the following procedures and durations, respectively:

- during installation procedures
- during any interruption of the installation procedures
- during the maintenance procedures
- during any interruption of the maintenance procedures
- during the duration between the end of installation and first commissioning
- during the duration between the end of maintenance procedures and recommissioning

Refer to chapter "Preservation and protection against corrosion".

C 2 Erection

We propose erection of the plant by Atlas Copco personnel.

The turbomachinery plant is erected as per the conditions specified by you and the resulting drawings which have been made available to you for comment/approval during order handling, the most important of which are the following:

- Foundation plan
- Layout plan/outline plan
- P+I diagram
- Documentation of instrumentation

CAUTION Erection and alignment off all units has to be done according to the axes given in the foundation plans and site coordinates.

C 2.1 Preparations, checks of foundation

You are obliged to observe any and all identification attached to packing, refer also to the instructions for transport, storage and preservation.

Unpacking of plant parts

If the turbomachine or its single parts/accessory are packed in wooden or cardboard boxes, open the packing with care. Doing so, make sure that you do not damage the parts with the tools you use in the process to ascertain proper operation of the parts in question. Whenever heavy parts must be lifted from boxes, ropes must be attached to them as specified to lift them properly.

Foundation checks

Check the following against the foundation and layout plan prior to commencing any erection work and record any non-compliance:

- In particular the anchor holes provided for installation of the base frame and the accessories must be checked for position, depth, distance to each other and from center and axes. Any deviations must be corrected, if required.
- Check foundation height of motor- or generator foundation if any.
- Remove water residues and other contaminants from the anchor holes. Remove any left over boarding material, which have been employed to board up the anchor holes. Afterwards clean the foundation and its adjacent area thoroughly.
- Protect the anchor holes against repeat contamination after they have been cleaned until the machine is installed respectively until they are grouted (cover or seal tightly).
- The plant grade line ± 0 or a related variant must be marked as binding by the construction supervisor in the erection area in question.

The foundation must only be loaded, i.e. the machine must only be erected on the foundation, after the setting time specified by the customer foundation contractor in charge of building the foundation has elapsed. Strict adherence to this time is mandatory.

Whenever non-compliance with regard to the foundation might affect AC’s scope of supply, it is up to the customer to decide whether he intends to modify either the foundation or AC’s scope of supply.

C 2.2 Assembly sequence

Details to the following working steps are described in the following chapters.

CAUTION Whenever welding works are carried out in the vicinity of the turbomachine special care has to be taken that the earthing of the welding machine is done in such way that no current can flow over the gear box / bearing carrier. The earthing point must be as close as possible to the welding point.

Assembly sequence

1. Erection of base frame and alignment
2. Grouting of anchor feet
3. Erection of separate lube oil system, if any.
4. Assembly/connection of gas piping loose
5. Assembly of water lines to/from all coolers
6. Check of gasline alignment - connect.
7. Assembly of driver/generator and coupling - align driver towards compressor/turbine



You are requested to adhere to manufacture's operating instructions for erection, assembly, operation and maintenance of the driver/generator.

8. Assembly of all other pipe work such as blow-off-line, oil piping etc.
9. Grouting of the base frame
10. Erection of panel/control board
11. Erection of separate panel/control board, if any

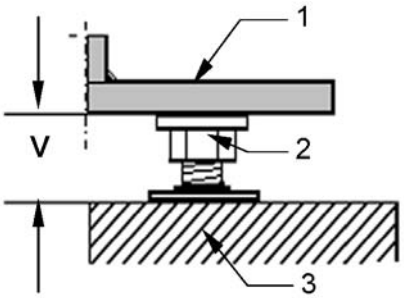
C 2.3 Positioning of turbomachine on foundation

Danger: suspended load/falling parts

May lead to severe injuries.

- Use only approved hoisting equipment and cranes of sufficient capacity. For information on weights refer to the foundation and layout plan, or information on packing.
- Employ special auxiliary equipment, e.g. traverses, loading joists, if specified.
- Use only undamaged ropes and chains.
- Protect the edges whenever hoisting chains or ropes are placed over edges of packing or machinery.
- Lifting eyelets are not always designed to receive the total weight. Pay attention to the information contained on their stickers.
- Secure parts against shifting during transport/handling.
- Observe the shift in center of gravity during transport.
- Refrain from standing below suspended loads.

Maximum adjustment of jack screw V = 57 mm, minimum V = 42 mm.



1 Base frame
2 Jack screw
3 Foundation

Bigger distances (foundation height too low) must be compensated by adding a shim of corresponding thickness on top of the jack screw.

Make sure that the provided grout may still be applied for the resulting new grouting height.

For machines exceeding a weight of 20 t, 3 - 4 steel supports of 50 mm thickness should be provided on each side to avoid damages to the jack screws in the event of unilateral positioning of the base frame. This will also greatly facilitate any shifts of the base frame for readjustment without using a crane.

Adjust jack screws to center position. For more details refer to manufacturer's description.

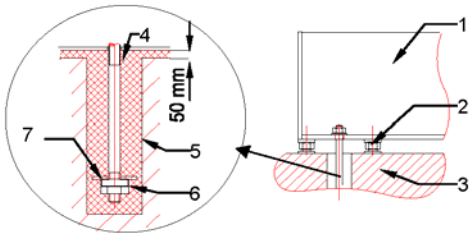
CAUTION Whenever grease has been employed to facilitate sliding, any surfaces of base frame and foundation that have come into contact with the grease must be thoroughly degreased after the steel supports have been removed.

Installation of base frame

1. Position jack screws as per foundation and layout plan prior to installing the turbomachine. The contact surfaces of the jack screws must be clean and level (retouch foundation, if necessary).

Horizontal alignment must always be carried out using a calibrated shaft water level, precision per scale interval = 0.1 mm/m.

2. Install base frame with anchor bolts in position. Then align to the co-ordinates and axes previously determined and bring to required height using the supplied jack screws. The anchor bolts have to protrude the top nuts by approx. 15 mm to enable optimum adjustment in height.



Drawings show example with two jack screws

1 Base frame
2 Jack screw
3 Foundation
4 Anchor bolt
5 Grout
6 Nut
7 Anchor plate

CAUTION The base frame has to be pre-aligned before grouting of anchor bolts. Distances and axes to other plant parts must be considered.

3. Grout anchor bolts. Setting time for grouts approx. 24 hours as specified in section “Grouting”. Then tighten anchor bolts and check and record alignment.

The base frame has to be grouted after all installation and connecting work has been completed (refer to section “Grouting”)

CAUTION When machinery is erected outdoors, alignment might be impaired by unilateral exposure to the sun.

C 2.4 Erection and completion of turbo machine plant

The sequence in which the turbo machine plant has to be erected depends on the plant concept and on the conditions prevailing on site, see assembly sequence. When erecting and aligning the gearbox, however, make sure to install heavy components, such as driver, cooler/s etc. at the proper point in time, as these will substantially affect alignment.

All measured values are to be registered in the gearbox/turbo machine base frame alignment record.

Mounting of the generator

The generator is mounted on a separate foundation.

Position the driver on the sole plates provided on the foundation and effect final alignment of the generator toward the gearbox. For vertical fine alignment use the delivered steel shims or compensating elements (Vibracon). Once the desired position has been reached, tighten screws firmly.



When aligning the generator observe marks and manufacturer's data as to mechanical and magnetic center.



You are requested to adhere to manufacture's operating instructions for erection, assembly, operation and maintenance of the generator.

C 2.5 Installation of accessories

Re-install and/or re-connect any and all turbomachinery parts that had been removed from the unit on account of transport restrictions (it is imperative to check set points).



Increased Fire Hazard due to explosive process gases (e.g. O_2, H_2, CO, …)

Solvents and lubricants that are not approved for these process gases must not be used.

After assembly, maintenance or cleaning of the turbomachine, and prior to commissioning, all plant parts and accessories are to be purged with clean, dry gas. This gas must be of a type that does not react with the process gas. Therefore, it has to be ensured that all dust, rust, foreign particles, liquids and all contamination incompatible with the process gas have been removed.

Measuring instruments approved for this process gas must be used only!

Installation of separate seal gas panel

CAUTION Check all internal pipe connections before erection of the seal gas panel for correct assembly.

1. Assembly of seal gas panel if necessary.
2. Mount the anchor bolts if applicable.

Refer to the foundation plan for the used fastening system.

3. Install the seal gas panel in position. Then align towards the turbo machine according to the foundation, layout and P + I drawing in the annex.

CAUTION The seal gas panel has to be pre-aligned before fixing the bolts. Distances and axes to the turbo machine must be considered (refer to foundation and layout drawing).

4. Assembly of all pipings

All pipe connections have to be loosely tightened.

5. Grout the anchor bolts or drill the holes for the dowels.
6. Bolt the seal gas panel to the foundation.
7. Tighten all piping connections.
8. Fix the seal gas panel frame.
9. Check all pipe connections for correct installation.

Document final alignment values.

Installation of separate oil system

Danger: suspended load

May lead to severe injuries.

When lifting the oil system, only use the lifting lugs/points provided on the base frame. Insert shackles into the holes.

After the turbomachine base frame has been erected and all gas piping has been connected, the oil system can be installed next to the base frame.

CAUTION Check all internal pipe connections of oil system before erection of the oil system for correct assembly.

1. Assembly of oil system if necessary.
2. Mount the anchor bolts if applicable.

Refer to the foundation plan for the used fastening system.

3. Install the oil system in position. Then align towards the turbomachine according to the foundation, layout and P + I drawing in the annex.

CAUTION The oil system has to be pre-aligned before fixing the bolts. Distances and axes to the turbomachine must be considered (refer to foundation and layout drawing).

4. Assembly of all piping



All pipe connections have to be loosely tightened.

5. Grout the anchor bolts or drill the holes for the dowels
6. Bolt the oil system to the foundation.
7. Tighten all piping connections
8. Fix the oil system frame

Document final alignment values.

Installation of pneumatic actuator

Whenever the actuator has been removed during transport, it must be re-installed as follows:

1. Remove the stroke indicator on the spindle.
2. Mount a provisional compressed air supply (including pressure reducing valve and manometer) for the diaphragm actuator.
2. Move the spindle carefully into the lower end position. Then lift it up again about 1 mm.
3. Place the depressurized stroke indicator carefully on the bracket and screw it down.

CAUTION The piston rod of the diaphragm actuator and the spindle must not touch. A distance of 1mm must be kept.
If necessary, move the diaphragm actuator by carefully pressurizing it until the ends of piston rod and spindle are at the proper distance.

4. Assemble the stroke indicator flush with the adjusting nuts (if provided) on the spindle.

CAUTION The stroke indicator must be positioned in the exact minimum position on the scale.
If necessary, move the spindle to set the exact position.

5. Vent the diaphragm actuator (if necessary) and remove the provisional compressed air supply.
6. Assemble the air piping between position controller and diaphragm actuator.

CAUTION Stroke limits, limit switch positions and position controller must be checked and re-adjusted prior to commissioning.

For information about installation, operation and maintenance refer to the manufacturer's operating manual in the annex.

C 2.5.1 Installation of pipes

For clear identification the pipes of the oil and water piping are numbered according to an established pattern. The numbers are listed and described in the relevant piping diagrams. Pipings and pipe sections will be marked with an adhesive label showing their position number.

CAUTION It is prohibited to weld components (such as supports, fastening devices) to plant parts supplied by AC.

For pipes which are manufactured on site, it is imperative to adhere to the application of proper materials with regard to correct dimensions, identification of materials, welding procedures, welding fillers, welding procedure qualification and inspection, see chapter works standards and quality requirements.

CAUTION Compliance with AC’s Works Standard on cleanliness is mandatory.

Prior to installing the suction nozzle or suction pipe, check proper operation of the inlet guide vanes, if any are installed.

When connecting pipework accessories, refer to subsuppliers manuals!

Pipes must be installed in a way that no or at least only negligible forces and torques are transmitted to the turbomachine (refer to layout plan/outline plan). For this reason, the use of expansion joints, flexible expansion joints and supports are highly recommended.

Whenever finished pipes are modified, these modifications have to be documented as specified (weld seams, x-ray films, pressure tests, etc.). These documents have to be sent to AC (Dept. 'Project Documentation') immediately.

Whenever the plant user has taken other actions to ensure that the permissible forces and couples are not exceeded at the turbomachine stage, regardless of the prevailing operating conditions, and given that all pipes are installed free of any stress, pipes may be installed without expansion joints.

All piping must be cleaned and treated prior to final assembly (refer to the Works Standard in the annex).

Manufacturing and customization of pipes on site

All work has to be done in accordance with ACE's Works Standards and specifications given in the annex.

Refer to following drawings in the annex:
- P&I diagram
- Layout plan
- Piping plan gas

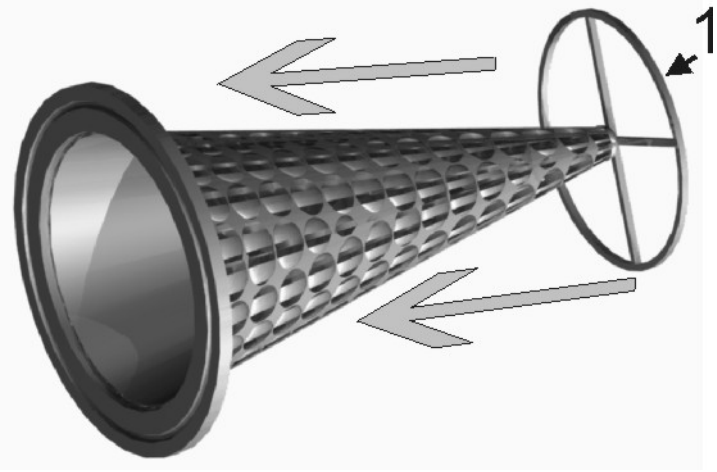
Welding must only be done by welders with valid approved certificate acc. PED.

1. Thoroughly remove paint from all surfaces to be welded.
2. Customize and weld pipes (acc. piping plan gas).
3. Perform an NDE test of the welding seams.
4. Test pipes under pressure acc. to QSV-QP-07.
5. Repaint the treated surfaces acc. . to 'ACE Painting Specification' (see chapter 'Works standards in the annex)

After all tests have been passed, the reports of the pressure tests and the NDE tests as well as the welders' certificates have to be sent to Atlas Copco to complete the Quality-Documentation.

Suction strainer

The filter element should be inserted into the tube or pipe in such a way that the fluid stream flows from the jet towards the flanges.



Depending on the nominal diameter, the sieve cone could weigh up to 80 kg. This necessitates the use of appropriate tools!

For nominal diameters above DN500 or 20", the sieve cones are fitted with ring-like assembly aids (1) to make it easier to insert them into the pipes.

CAUTION The flange sealing surfaces should not be damaged!

C 2.6 Electrical connections

Most of the electrical components installed on Atlas Copco turbo machineries have been pre-wired.

The customer is advised to wire driving motors, all turbo machine accessories and the control panel as per the instructions for instrumentation contained in the annex.

CAUTION Cable connections and guards must be installed according to layout plan and wiring diagram. It must be absolutely ensured that cables are not damaged by vibrations.



Danger: electric voltage

May lead to lethal injuries.

- Prior to working on electrical equipment, de-energize the plant.
- Work on power plants must only be carried out by expert personnel.
- When de-energizing units, do not forget auxiliary circuits, e.g. standstill heatings.
- Make sure to protect switches against re-activation when de-energizing units.
- Isolate or cover any adjacent life parts.

C 2.7 Anti-frost measures

Protect your plant against frost. Any additional trace heaters for water pipes, measuring lines, instruments, etc. must be provided by the customer.

Alignment by means of laser system

Whenever alignment is carried out by a means of laser system, particular attention must be paid to the system description and system instructions. Early preparation and provision of the equipment required in each single application is mandatory.

CAUTION Special equipment is required for explosion-proof areas.

Tolerance (ACE formula) for optimum cold alignment 0.01 mm/100 mm measurement diameter.

1. For radial alignment, the different growth in height between centrifugal turbo machine and driver, depending on the concept of the plant and the driver type, must be determined and/or considered in the measurement (refer to alignment protocol to determine difference in height).
2. Measure “L” = distance between the shaft ends has to be complied with in consideration of the magnetic center (electrical drivers) and the axial clearances. This measure “L” is shown in the layout plan. For more details, refer to the corresponding coupling drawing.
3. The determined difference must be corrected by adding shims below the driver feet subsequent to each measurement. The measurements and corrections have to be carried out, until measured values are within the acceptable tolerance.



Adherence to the instructions for use of the laser system is imperative. These instructions contain invaluable advice on which parameters are required and have to be entered for correct alignment between driver and driven machine.

During alignment, some laser systems could be assembled and switched on. Thereby the relevant alignment values will be shown immediately.



For information on cold alignment of the machine unit (increase in height, axial clearances) refer to the annex. An alignment record is handed over to the plant user after final alignment.

Installation dossier, records and measuring devices and instruments



All measuring devices and instruments must be checked and calibrated.

- All measured values, in particular final alignment checks, have to be diligently registered in the relative records and must be added to the site documentation and/or the final installation record (for forms and examples refer to the annex).
- Complete documentation is indispensable on account of quality demands, in particular as far as alignment and its impact on the contact pattern of the tooth flanks and the vibration quality are concerned. For this reason, alignment checks must be repeated prior and during commissioning and during revisions, if possible.
- For better long-term observation of gear contact patterns (contact patterns of tooth flanks, in particular after prolonged operation and during major revisions), the indications (coats of varnish on at least 5-6 teeth of bullgear and pinion shafts) must be checked and the results be documented.

C 2.8 Grouting

Foundation anchors of turbomachinery have to be grouted as per the instructions contained in the individual foundation plans.

The type of grout to be used must be specified at an early point in time to ascertain timely provision of required quantities, including equipment/assistants.

Grout

”Shrink-free grout” with high interim and final strength must be used for normal grouting heights of 50 mm.

General reference values for a.m. grouts:

Pot life after preparation	≈ one hour (at + 20 °C)
Minimum application temperature (also components)	≥ + 5° C
Dry mortar, weight	≈ 1.900 kg/m^3
Compressive strength after one day	≈ 50 N/mm^2
Compressive strength after 28 days	≈ 90 N/mm^2
Flexural and tensile strength after one day	≈ 6 N/mm^2
Flexural and tensile strength after 28 days	≈ 9 N/mm^2

Compliance to regulations/ manufacturer's instructions regarding special features, e.g.:

- Application (in particular grout height, grout surface)
- Processing (mixing ratio, build, pot life)
- Cleanliness and post-treatment

Examples of some brand grouts from the ACE vendor list (revision 1996):

Barra, Betec, Chockfast, Five Star, Pagel, Sikkens-Epoxy, Tricosal VGM, etc.

When comparable grouts are not available, e.g. abroad, the AC Parts and Service department should be contacted early to initiate special action. Examples for special action:

- Increase the number of jack screws,
- Select equivalent grout, if recommended brand is not available
- Recommend composition of grout
- Special action for preparation/filling in of grout
- Modify setting time etc.

C 3 First commissioning

This procedure must be followed for the original first commissioning, after plant overhauls and repairs!

Responsibility

All first commissioning activities have to be done under supervision of the Atlas Copco commissioning engineer, who ensures, that all activities are in accordance with the appropriate safety regulations.

'Cold' commissioning will be carried out with mechanical, electrical or instrumentation assistance from client personnel.

'Hot' commissioning will be carried out in co-operation with the client's process responsible.



May lead to severe injuries or death.

Devices and equipment used for explosion protection must not be manipulated.

Prior to commissioning and during operation it must be absolutely ascertained that potential sources of ignition cannot be generated in the explosive atmosphere, such as:

- mechanically generated sparks
- electrostatic strokes
- hot surfaces
- chemical reactions
- flames and hot gas
- arcs and lightning
- ionizing radiation
- electromagnetic waves
- optical radiation



Increased Fire Hazard due to explosive process gases (e.g. O_2, H_2, CO, …)

Solvents and lubricants that are not approved for these process gases must not be used.

After assembly, maintenance or cleaning of the turbomachine, and prior to commissioning, all plant parts and accessories are to be purged with clean, dry gas. This gas must be of a type that does not react with the process gas. Therefore, it has to be ensured that all dust, rust, foreign particles, liquids and all contamination incompatible with the process gas have been removed.

Measuring instruments approved for this process gas must be used only!

C 3.1 Preparations

Prior to commissioning turbomachinery plants, check the plant and all its components as follows, even if they are not expressly mentioned:

- All parts must be clean. If required, clean as described in chapter „Maintenance“.
- Check alignment. Ensure that the plant was erected as per relevant drawings.
- Check proper operation of all shut-off valves.

Pressure and leak test

A pressure and leak test has to be carried out for the turbomachine and the complete pipe system at design pressure.

Check of earthing and shielding

- Central earthing point of the turbomachine base frame
- Central earthing point of the main electrical machine (driver/generator)
- Central earthing of all junction boxes and panels.
- Protective earthing of all auxiliary motors
- Protective earthing of all solenoid valves if applicable
- Protective earthing of all junction boxes and panels
- Shielding ground for all junction boxes and panels

Check of electrical drives for correct direction of rotation

CAUTION The check for correct direction of rotation must only be effected in uncoupled state. All machinery must be turned by hand.

Refer to direction of rotation arrows at gear, or to information on gear drawing.

Check auxiliary drives for correct direction of rotation by means of the arrows. Rotating parts must not contact the driver guard.



Reading manufacturer’s instructions before commissioning the motor/generator is mandatory.

Check of lubricating system

- Check oil filling level (oil level at "full" mark).
- Fill the oil demister syphon (10 litres per syphon), if any.

If the machine has not been in operation for a long period of time, check the quality of the oil. If it complies with the specification, it may remain in the plant, otherwise it must be changed.

CAUTION Lubricants, oils and greases must comply with the requirements specified in the supplier manuals or standards. For details about fillings and consumption see also in chapter "Maintenance".

C 3.2 Procedure

- In order to perform the commissioning of a complete system under process conditions the control system structure must be tested first for power supply, including earthing, communication between operator panels and process logic control and function of the bus system.
- Next, conduct the cold commissioning of the control system without medium. This includes functional checks of the analogue and binary measurements, drives, heaters, demister and valves.
- All measurement ranges and settings are checked against the set point list.
- The sequence of the function blocks and the complete control sequence will be tested under consideration of interlocking, alarms and trips according to the logic function diagrams.
- All the checks are applied to the panels with the related field installation and equipment.

C 3.3 Commissioning of the control system

CAUTION The coupling of the main electric machine (driver/generator) must be disassembled during first commisioning.



Some of the systems have already been checked at the workshop. They need not be checked again at site.

Refer to 'Check list for commisioning' in the annex.

Earthing

Check the following points:

- Central earthing point of all cubicles and panels.
- Shielding ground for all cubicles and panels.

Power supply work shop tests and inspections

The following tests have been performed after manufacturing of the junction box:

- Electrical safety inspection
- Dielectric voltage inspection
- Inspection of power supply
- Inspection of function

Test of the cubicle power supply

1. Verify that all required power supply cables are connected to the terminals.
2. Verify the insulation of all supply cables.
3. Ensure that all main switches are turned to their OFF-position
4. Check that all circuit breakers are disabled.
5. Request the client to energize the power supply cables.
6. Check all supply lines for the correct voltage level on the related terminals.

Energizing the cubicles

1. Turn the main switch to the ON-position and check power supply to the connected circuit breakers.
2. Selectively turn on the circuit breakers related to the cubicle internal transformers and power supply units to put them in service.
3. Record the secondary voltage level on the transformers and power supply units to ensure they are working correctly.
4. Record the polarity of the output of the power supply units.

Process logic control and operator panels

- Visual Check of the PLC and the operator panel
- Function test of operator panel
- Function test of PLC
- Functionality of bus system

Function test of analogue and binary signals

- Check PLC - Input and signal indication on the operator panel.
- Check measurement ranges, alarm and trip settings of the analogue signals.
- Check correct indication of the binary signals on the operator panel.

C 3.4 Cold commissioning

The cold commissioning will be carried out step wise, starting with function check of all loops, commissioning of all drives and auxiliaries, followed by function block tests and finishing with sequential control.

General test prerequisites

- All required power lines are in service
- Commissioning of the control system structure is finished
- All loops to the field measurement devices are powered up
- All open loop indications (broken wire alarm) of the field measurement devices on the operator panel are cleared

Calibration of transmitters and switches

A calibration check of transmitters and switches should be carried out (if not done yet).

- The indication of the simulated process value on the monitor should match with the set value of the test equipment.
- The indication of the status change on the monitor has to be checked if it switches at the adjusted setpoint.

C 3.4.1 Auxiliary devices

Test prerequisites

- The necessary medium for the auxiliary devices is provided.
- All necessary binary and analogue signals are tested.

Pneumatic actuators

The test will be applied for all pneumatic actuators:

- Adjustment of the PICV to the designed working pressure
- Mechanical adjustment of required actuator stroke
- Adaptation of the positioner to the system via internal positioner display
- Test of control signal to the actuator
- Test of the positioner feedback signal, if applicable
- Adjustment and test of the actuator limit switch
- Check actuator for air leakages

Solenoid valves

Check for proper operation of all solenoid valves.

Lubricating oil pump (electric driven)

1. Check setting of motor protection relays.
2. Check direction of rotation.
3. Start the pump and check the oil system pressure and tightness.
4. Adjust pressure control valve and pressure safety valve.

Lubricating oil heater

1. Check setting of heater protection relays.
2. Start heater and check if the temperature is increasing.
3. Adjust temperature controller.

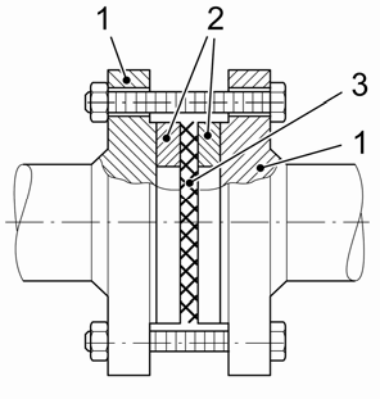
Demister with fan

1. Check setting of motor protection relays.
2. Check direction of rotation.
3. Check vacuum.

C 3.4.2 Flushing of lubricating oil system

CAUTION If parts of the oil system were disassembled or reassembled for any reason, such as to facilitate transportation to the site, or for maintenance operations, etc., the oil system of the turbomachine must be flushed prior to first commissioning or recommissioning.

- Visually inspect the oil tank, remove any contamination and foreign matter.
- Visually inspect pipe, oil filter/s, and oil cooler/s.
- Install the intermediate filter/s directly upstream of the gearbox (or bearing carrier) and upstream of the connection to the driving machine. Filter mesh size ≥ 50 µm ≤ 100 µm. Then, install the intermediate filter/s (3) between the connecting flanges (1). A collector vessel must be placed below this connection to collect any leakages occurring during flushing.



The intermediate filter (3) must be glued between two sealing disks (2) (e.g. using sealing glue Rhodosil, refer to sketch). Pay attention to glue drying time.

It is imperative to adhere to the main driver manufacturer's instructions relative to flushing.

If the oil pipes or oil coolers are delivered in dismantled state for transport-related reasons, they must be checked for contamination and cleaned prior to being installed, if necessary.

- Fill in oil as specified in the AC specification into the oil tank up to the MAX mark. If this is a first filling, consider the volume of the pipes.
- Energize oil heating and heat oil to minimum temperature.
- Switch on cooling system of oil cooler.
- Switch on seal gas system, if any.
- Switch on demister, if any.
- When using dual oil filters, adjust change-over fitting to only one single oil filter.
- Start auxiliary oil pump.
- Flush oil system for at least 2 hours while observing the differential pressure indicator of the oil filter. If the differential oil pressure exceeds the max. mark, stop the oil system and replace and clean the intermediate and oil filters, if necessary.

CAUTION Oil might emerge from the inspection opening. Take associated action to protect staff and environment.

Check the piping system for leakages when flushing. Check for increased bearing temperatures. Check oil return (at sight glass in oil return pipe, open inspections cover of integrally geared turbo machines, if necessary, and make sure that gearbox gears are lubricated with oil).

- If dual oil coolers are installed, flush the first oil cooler for 30 minutes, then change over to the second oil cooler.

CAUTION Oil might emerge from the oil pipes when they are opened. Take associated action to protect staff and environment.

- Stop oil system, replace intermediate filter/s upstream of gearbox/bearing carrier and driving machine.
- Change over dual oil filter/s to the oil filter currently not operating.
- Remove, clean or replace the previously flushed filter element, if necessary.



If a single oil filter is installed, stop the auxiliary oil pump after the first flushing sequence has been terminated or earlier if the differential pressure across the filter is too high. Inspect and replace the filter cartridge, if necessary.

- Re-start oil system and keep operating for at least 24 hours. Observe differential pressure indicator of oil filter. If the differential pressure exceeds the max. mark, stop the oil system and clean intermediate and oil filters.
- If there is no more increase in differential pressure, stop the entire oil system.
- Remove intermediate filter/s. Clean oil filter/s. If necessary, install new filters for operation. Operating position for dual oil filters and dual oil coolers: only one element must be operating, the other one must remain idle.
- Take an oil sample after 200 operating hours of the turbomachine (refer to chapter oil inspection).

C 3.4.3 Control sequences

Test prerequisites

- All function blocks are tested according to the above mentioned procedures.
- All function blocks are in service or enabled to be operated.
- Main driver of turbomachine is in the test position, if any.
- Simulation of the required plant conditions.

Test procedure

- Test of the turbomachine start up interlocks.
- Test of the turbomachine start and stop - sequences.
- Verification the of turbomachine control logic.
- Simulation of the turbomachine trip conditions.
- Test of all signals between main driver-DCS and turbomachine-PLC, if any.

C 3.5 'Hot' commissioning

General test prerequisites

- Cold commissioning of the turbomachine is finished.
- All function blocks are in service or enabled to be operated.
- The designed process medium is available to be handled by the turbomachine.

CAUTION Before the first start of the turbo machine all alignments have to be rechecked and corrected if neccessary.



The turbomachine must not start with hazardous gas/air mixtures. This may cause an explosion which can cause severe personnel injury or death.

The process piping system must be purged of all process gas before starting the turbo machine.

Purging is required if any of the following cases are present or have occurred:

- before initially starting the turbo machine
- the control system power has been interrupted
- the process gas pressure has dropped below the suction pressure



Refer to Chapter 'Operating instructions' for purging procedure instructions.

C 3.5.1 Preparation

- Before operation all safety controllers of the turbomachine are to be adjusted.
- Vent and fill components in a safe way.

Suction strainer

After proper assembly of the suction strainer, the flow may be stepped up slowly, starting from zero. While doing so, the differential pressure (pressure head) at the filter element should be monitored constantly. If this increases beyond the permitted value, the flow should be withdrawn immediately, the cause determined and corrected.

CAUTION If the differential pressure far exceeds the permitted value, the filter element will collapse!

C 3.6 Hand-over to user

The machine is handed over to its user after the acceptance test run has been successfully concluded. The hand-over record certifies perfect operation of the plant. Machine and plant data are registered in these data sheets a copy of which is submitted to the Atlas Copco Parts & Service Center.

From this moment on, the plant user assumes full responsibility for the machine plant.

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D 1 Special instructions for safe operation

CAUTION If the turbomachine is to be started again after a longer standstill period (more than 7 days), all items are to be checked in the same manner as during first commissioning.

The turbomachine must be operated only by trained staff to rule out any and all gross negligence. Please pay close attention to the safety instructions included in chapter Safety.

The general work place of the machine operators is the control room. Only in exceptional cases will operators be required to stay in close vicinity to the machine for a short time, such as during the startup procedure.

When machines can be started and stopped only locally, i.e. on the machine itself, the immediate surrounding of the machine is regarded as the work place.



Danger by noise.

The communication may be disturbed by noise. This causes danger for the staff.

- Never operate the turbomachine when doors or covers, e.g. of silencing hoods, if any, are still open.



Always wear ear protection



Danger by insufficient safety devices.

Might lead to lethal injuries.

- Check proper operation of alarm and safety devices prior to any turbomachine start-up. You are obliged to immediately report any irregularities to your company senior that you are not in a position to eliminate by yourself.
- Never inactivate safety devices.
- Make sure that the guards of live, rotating, hot or cold parts have been properly mounted.
- Make sure that valves or flaps cannot be involuntarily opened or closed (by signs, mechanical interlocks).
- Turbomachines must not be started up, if the start-up conditions do not comply with plant data or the plant process and if plant data have not been expressly checked.



Danger by escaping compressed process gas.

May lead to lethal injuries.

During operation of the turbomachine

- Maintenance work must not be carried out
- Valves or plugs must not be opened
- Pipe connections must not be opened.



Danger by fire.

May lead to poisoning, severe burns and overload of machine components.

- Implement sufficient fire protection and prevention measures.
- Provide adequate fire extinguishing equipment and measures to protect your staff.

D 2 Impermissible operation



Danger by bursting impellers and casings.

Might lead to severe injuries.

- The turbomachine must not be operated at speeds, pressures and temperatures other than those specified.
- It is absolutely prohibited to change set points which will result in machine trips.

CAUTION Danger by component overload might severely damage the turbomachine.

- The turbomachine must not be operated at ambient conditions other than those stipulated in applicable specifications. In such cases, the AC Parts & Service Centre must be contacted, as materials, clearances etc. might be insufficient for these conditions.
- The gas must not be polluted by solid, liquid or gaseous particles.

Suction strainer

With time, the filter mesh gets clogged with the filtered out particles, which manifests itself as an increasing differential pressure.

Hence, it is important to constantly monitor the differential pressure over the filter element (or at suitable, regular intervals).

Latest at the time the differential pressure touches the maximum permitted value, the filter element should be dismantled for cleaning.

CAUTION The filter element may only be operated with suitable safety installations, which exclude any kind of overloading beyond the permitted operating conditions, at any time.

CAUTION Danger of damage to plant parts caused by frost.

Proceed as follows to ensure that plant parts such as pipes, coolers, and measuring pipes cannot freeze in winter:

- Vent coolers
- Drain condensate
- Switch on water supply
- Install trace heater
- Provide oil tanks and pipes with sufficient insulation
- Isolate oil system, heat it

D 3 Permissible operation

This turbomachine has been designed to be operated at the operating conditions specified in chapter "Technical data".

D 4 Maintenance during operation

Good supervision of operation is ascertained by close observation of the turbomachine while it is operating, the correct operation of measuring instruments and controlling devices and by continuous and regular registration of measured values.

Furthermore, the following events should be registered and logged, inclusive date and time:

- Any start-up
- Any shutdown
- Any overhaul, repair, revision
- Any cleaning of filters and coolers
- Operating data

CAUTION The following maintenance plan serves as an example.

A binding maintenance plan must be developed by the user as part of a operator’s handbook in due consideration of the maintenance intervals specified by AC and AC's subsuppliers.



For information on maintenance, refer to AC’s and AC's sub-suppliers maintenance plans in Chapter "Records, forms and check lists" and "Technical documentation and instruction manuals of AC's sub-suppliers”.

D 4.1 Maintenance schedule during operation

Depending on the scope of supply, some of the following items may not be installed in your machine.

CAUTION Should deviations from normal operation be detected during the course of the daily turbomachinery inspections, corrective action must be taken immediately. Depending on the nature of the deviation, either expert staff or AC service personnel must be consulted.

Maintenance work	by	When				
Functional test of safety devices	W	In regular intervals, e.g. to the accident prevention regulation and after modifications or inspections				
		every 4 hours	daily	monthly	annually	every 2 years
Check function of control mechanism (IGV, DGV, control valves, nozzle ring)				X		
Register operating data	B/DCS	X				
Check oil level (oil tanks)**	B		X			
Check oil supply motor/Generator*	B		X			
Check all filters/strainers for fouling	B		X			
Check condensate trap, drain condensate (unless done automatically)			X			
Check turbomachinery for irregular noise, loose screw and cable connections, etc.			X			
Check plant for gas, water and oil leakage	B		X			
Check of lubricating devices (relubricating tank, bladder accumulator)	B			X		
Oil inspection	B	according to lubrication schedule				
Compare operating data displayed	AC				X	
Inspect plant	AC					X

AC = AC personnel B = customer experts W = maintenance staff

* For further information refer to sub-suppliers manuals.

** If the oil level in the oil tank increases, the oil cooler must be check for cooling water leakage.



For more detailed information on lubricants to be used and detailed preventive maintenance, refer also to chapter „Maintenance“ and “Workstandards”.

D 5 Operating instructions

The subsequent instructions include the prerequisites and the sequence of activities required for the provided operating mode.



For location of operating elements, refer to the description of the control system.

D 5.1 Turbomachine purging procedure



The turbomachine must not start with hazardous gas/air mixtures. This may cause an explosion which can cause severe personnel injury or death.

The process piping system must be purged of all process gas before initially starting the turbomachine.

Purging is required if any of the following cases are present or have occurred:

- the control system power has been interrupted
- the process gas pressure has dropped below the suction pressure

A typical purging is accomplished by manually pressurizing the system and then venting the contents to a pressure slightly above atmospheric 0.1 to 0.2 bar(g). Each purge cycle will reduce the concentration of process gas proportional to the purge pressure used.

Lower purge pressures require a greater number of cycles. The number of purge cycles is determined by calculating the number of cycles needed to reduce the process gas concentration below the critical concentration and then adding one additional cycle.



Depending on the employed fluid, check measurements have to be carried out at the highest/lowest point of the system to be purged.

CAUTION The auxiliary oil pump must be turned on in case the venting of the process piping causes rotation of the turbomachine. The vent valve should be opened slowly to prevent any turbomachine rotation.

CAUTION The purge gas must also be admitted to the system to be purged via the purge/seal gas filter of the shaft seal and gear box purge connection, if applicable.

Extract from "Functional description"
Rev. 2 (dated 2011-09-14)
by C. Banik

D 5.2 Pre-Checks

D 5.2.1 General Pre-Checks

- Verify that the pre-commissioning procedures for the ETG are completed. Refer to operating manuals for further information.
- Verify that the Pre-start up safety review has been completed.
- Verify position and operating mode of the controllers.
- Verify all root valves and blinds are in the correct position.
- Verify status of trip signal values.
- Verify all protective devices are operative.
- Verify that the control voltage is energized.
- Verify that instrument air is available and the isolation valves in the instrument air supply lines are open.
- Verify that separation gas (nitrogen) is available and the pressure control valve in the separation gas supply line is adjusted.
- Verify the aux. devices are released
- Verify cooling water is available

D 5.2.2 Checks Related to the Oil System

- Verify oil quality is according specification
- Verify level in the oil reservoir is > LAL.
- The oil systems is fully operative
- Verify the lube oil filters have been filled with oil, vented and one filter has been selected as filter in duty.
- Verify the oil side of the oil cooler has been filled with oil and has been vented. Verify the water side of the oil cooler has been filled with cooling water and has been vented. Flow cooling water to the oil cooler must be established.
- The lube oil reservoir heating is activated and in control mode “READY” respectively “ON”. It should always remain in control mode “READY” respectively “ON” during ETG standstill.

D 5.2.3 Checks Related to the Process Loop

- The manual block valves in the expansion turbine inlet and outlet pipe are open
- The system is purged with N_2 and afterwards pressurized with process gas up to the trip valve
- Prior to ETG start-up, ensure that all prerequisites for plant operation have been completed. To prepare the ETG for start up follow also customers instructions

D 5.2.4 Checks Related to the Generator

- Verify the system is purged with instrument air
- Verify the water side of the generator coolers has been filled with cooling water and has been vented. Flow cooling water to the generator coolers must be established.

D 5.3 Start-up Preparation

Press the function key on the HMI to release all auxiliary devices.

If

- the function key to release the aux. systems is pressed

The expansion turbine control system triggers the following actions:

- The lube oil reservoir heating is automatically activated and the indication on HMI changes from “LOCKED” to “READY / ON”.
- Bring the ETG in condition “READY TO START”
- Verify the temperature in the oil reservoir is >5°C.
  If the temperature in the oil reservoir is too low electrical failure of the oil pump is likely due to overload
- Verify separation gas is available
- Verify process gas is available
- Start the aux. lube oil pump from LCP or HMI
- Check the lube oil supply pressure is controlled at 2,5bar(g)
- Verify lube oil from the gear box is flowing back to the oil reservoir.
- Verify vacuum of approx. -15mbar is established in the lube oil reservoir

D 5.4 Ready to Start Condition for the ETG

- The auxiliary oil pump is ON, verified by running feedback signal.
- The oil mist separator fan is ON, verified by running feedback signal.
- The pressure lube oil gear box inlet (2oo3) is > PAL for at least 120sec (fixed time)
- The temperature lube oil gear box inlet (2oo3) is > TAL
- The level lube oil tank is > LAL
- The nitrogen pressure separation gas is > PAL
- The flow seal gas stage 1 and 2 are > FAL
- The pressure ETG inlet stage 1 is > PAL and < PAH
- Expansion turbine inlet nozzles stage 1 are closed, verified by position feedback < 5%
- The trip valve is closed, verified by position limit switch (energized)
- The start up valve is closed, verified by limit switch (energized)
- OK-Relay Bently Nevada is energized
- No measurement failure interlock is active
- No trip alarm is active
- No emergency stop is active
- T3 (coast down time) has elapsed
- Level in condensate trap generator cooler is not high LSH
- Purge Unit Generator is NOT PURGING AND purging must be COMPLETE

If all these conditions have been met the expansion turbine control system triggers the following actions:

- The HMI will indicate “READY TO START”



Automatic start-up

May lead to lethal injuries.

Turbomachinery provided with a remote start-up option must be equipped with a signal to indicate readiness for machine start-up. Such machinery may be started up at any time. Leave the hazardous area at once.

D 5.5 Start of the ETG

ETG start up

- If the ETG is ready to start push the START button

The expansion turbine control system triggers the following actions:

- The indication READY TO START is switched off.
- The indication ETG RUNNING is switched on
- One oil mist separator fan will be interlocked on.
- The auxiliary lube oil pump will be interlocked on.
- T1 is triggered (start up supervision time).

The expansion turbine control system triggers the following actions:

- The synchronizing controller W505E is released controlling the speed of the main shaft acting on the start up valve FV G103. The start up valve starts to open.
- The HMI indicates “ETG START UP”.



If the speed main shaft did not rise above 100RPM within T1 (start up supervision time), the expansion turbine control system will trigger a trip (speed limit and duration of T1 will be adjusted during commissioning).

The critical rotor speeds 436 – 805 RPM will be monitored and must be passed within 10 seconds, otherwise a trip is initiated. The binary output from W505E (IN CRITICAL BAND) will be transferred to PLC.

If

- the speed main shaft is >1200RPM

The expansion turbine control system triggers the following actions:

- The digital output TRIP MULTIPLY BENTLY NEVADA will de-energize. The vibration multiplier in the Bently Nevada vibration monitoring system is set from 3 to 1.
- The digital output EXCITER OFF de-energizes. The digital output EXCITER ON energizes. The excitation voltage of the generator will be switched on.

If

- The speed main shaft has reached synchronizing speed.

The expansion turbine control system triggers the following actions:

- The function keys on the HMI to start and stop the automatic synchronization sequence will be released.
- The W505E digital output SYNCHRONIZE ENABLE is energized.
- The HMI indicates “SYNCHRONIZING”.

During auto synchronization the synchronizer will energize and de-energize the digital output signals to the expansion turbine control panel causing the speed set point of the sync controller W505E to increase and decrease in steps of approx 5RPM within the given limits (steps for speed increasing / decreasing adjusted during commissioning).

While synchronization is in progress the digital input SYNCHRONIZING IN OPERATION is energized. Synchronization must be established within a certain time (approx. 600sec) otherwise the automatic synchronization will stop. The digital input SYNCHRONIZING FAULT is triggered. The digital input SYNCHRONIZING IN OPERATION de-energizes.

An alarm will be triggered in the expansion turbine control panel. If the alarm is acknowledged the auto synchronization is re-started automatically.

Manual stop of the automatic synchronization is possible at any time via the function key “SYNCHRONIZATION STOP” at the HMI.

If

- the function key “SYNCHRONIZATION STOP” at the HMI is pressed

OR

- the digital input SYNCHRONIZING FAULT is triggered

The expansion turbine control system triggers the following actions:

- The digital output STOP SYNCHRONIZATION is triggered
- The digital output START AUTO SYNCHRONIZATION is de-energized
- The HMI indicates “SYNCHRONIZING STOPPED”.

If

- the generator is synchronized with the grid

The synchronizer triggers the following action:

- The digital output signal GENERATOR SYNCHRONIZED energizes
- The signal to close the generator circuit breaker energizes and the generator circuit breaker closes.

  The GCPP Panel has a selector switch for AUTO, REMOTE or MANUAL operation. If the selector switch is set to AUTO, synchronization will be done automatically by SIPROTECT device in GCPP. If selector switch is set to MANUAL, synchronization can be done from GCPP control panel manually (requirements for synchronization will be monitored by SIPROTECT). If switch is set to REMOTE, synchronization can be triggered (Start/Stop) from PLC panel (Alan Bradly), synchronization is done by SIPROTECT device. A stop of synchronization is possible at any time from GCPP or PLC. A start of synchronization can be done from PLC (if REMOTE is selected) at GCPP selector switch, or – if switch is set to AUTO or MAN – from GCPP Panel (start synchronization pushbutton).

If the generator is successfully connected to the grid and the generator circuit breaker is closed the digital input GENERATOR CIRCUIT BREAKER CLOSED must energize. The digital input GENERATOR MCB CLOSED to W505E is energized

The time delay between closing the circuit breaker and energizing the signal GENERATOR CIRCUIT BREAKER CLOSED should be maximum 3sec.

If

- the digital input GENERATOR CIRCUIT BREAKER CLOSED is energized

The expansion turbine control system triggers the following actions:

- The digital output SOLENOID TRIP VALVE SV G102 energizes. The trip valve FV G102 opens (opening time is adjusted via needle valve installed in the instrument air supply line).
- Ramp 2 release the controllers acting on expander nozzles.
- Ramp 3 is triggered to ramp from 100% to 0%. The bypass controller output variable will follow and close bypass pressure control valve FV G113. If ramp 3 has reached 0% FV G112 is closed (verified by limit switch). If FV G112 is closed, software switch S1 is toggled and output to bypass valve will follow calculated output of polygon function 2.
- After a time delay of approx 120sec the output value of W505E is set to 0%. The output signal of the sync speed controller W505E will be limited and the start up valve FV G103 will close.
- The space heater of the generator is switched OFF
- The auxiliary lube oil pump will be switched off.
- The indication GENERATOR ON energizes

D 5.5.1 Monitoring during operation

We recommend that important operating parameters which give information on turbomachine operating behaviour are recorded in regular intervals. Deviations from normal operating data require close examination.

Any alarms and trips must be recorded with date and time.

Alarms Various alarm functions are provided in the turbomachinery plant. Whenever one of the set alarm values is exceeded or fallen below, an alarm message is triggered action for remedy must be taken, refer to chapter "Possible faults, causes and correction".

Trips Trips will directly shut the turbomachine down. Refer to the set point list in the annex.

The reasons for the occurrence of trips must be eliminated prior to any re-start.

CAUTION Whenever turbomachinery has been tripped on account of high shaft vibrations, it may only be re-started, after the reason for the trip has been found and assessed to be non-hazardous by expert staff. The company senior must be informed prior to any re-start.

Potential reasons for such trips might be:

- Measurement errors,
- Surging (of compressors),
- Instantaneous unbalance or
- Severe damage to the rotor,

If it turns out to be impossible to find the reason for the trip, we recommend to inspect the turbomachine.

D 5.6 SOFT STOP of ETG

Press the push button SOFT STOP

The expansion turbine control system triggers the following actions:

- Bypass valve FV G113 is still at calculated value of polygon function 2 and will be set to the output of ramp 3 (0% = bypass valve closed).
- Bypass flap FV G112 is opened when bypass valve FV G113 has reached the output value 0% (+/- 5% hystersis) of ramp 3.
- Ramp 2 is triggered and ramps from the actual value to 100%. The bypass pressure controller is released and bypass valve will take over load to process.

If ETG stop has been triggered

- Software switch S1 is set to the output of ramp 2 (0%)
- Time until positioner FV G113 reached 0% after soft stop is started

If Time until positioner FV G113 reached 0% after soft stop has elapsed

- Ramp 2 is triggered and ramps to 100% releasing bypass pressure controller

If Ramp 2 has reached 100%

- Ramp 1 is triggered and ramps to 0% closing the nozzles.

If Ramp 1 has reached 20%

OR

Power of generator drops below 5% (monitoring of generator power starts when ramp 2 starts to run from 0 to 100%)

The expansion turbine control system triggers the following actions:

- The solenoid valve SV G102 is de-energized and trip valve FV G102 is closed
- The generator is disconnected from grid
- The auxiliary lube oil pump will be switched on and remains interlocked on for the duration of T4.
- The start-up solenoid valve SV G103 de-energizes. If the start up valve FV G103 was open it closes.
- Stop signal to W505E is triggered and start up valve is closed if it has not already been reset (with GENERATOR MCB CLOSED plus 120 seconds elapsed).
- Ramp 2 is set to 0%. The nozzles of both stages close.
- The solenoid valve SVG104 de-energizes and nozzles stage 1 close.
- The digital output EXCITER OFF energizes. The digital output EXCITER ON de-energizes. The excitation voltage of the generator will be switched off.
- The generator must be disconnected from grid (generator circuit breaker must open) with a time delay of maximum 1 second.

If the generator is disconnected from the grid and the generator circuit breaker is open, the MCC will de-energize the signal GENERATOR CIRCUIT BREAKER CLOSED

If

- the digital input signal GENERATOR CIRCUIT BREAKER CLOSED de-energizes

The expansion turbine control system triggers the following actions:

- The oil reservoir heating is activated
- The generator space heater is switched ON.
- The indication GENERATOR ON de-energizes

If

- the trip valve is closed, verified by position limit switch energized

AND

- the start up valve is closed, verified by limit switch energized

The expansion turbine control system triggers the following actions

- T3 (coast down time) is triggered. The aux. lube oil pump is interlocked on for the duration of the coast down time T3.
- T4 (re-lubricating time) is triggered. The auxiliary oil pump is interlocked on for the duration of the re-lubricating time T4.
- The indication ETG RUNNING is switced off.

If

- the speed main shaft is < 1200RPM

The expansion turbine control system triggers the following actions:

- The digital output TRIP MULTIPLY BENTLY NEVADA will energize. The vibration multiplier in the Bently Nevada vibration monitoring system is set from 1 to 3.

If

- the coast down time T3 has elapsed,

AND

- the speed main shaft rises > 5RPM

The expansion turbine control system triggers the following actions

- An alarm is triggered

If

- the re-lubricating time T4 has elapsed,

The expansion turbine control system triggers the following actions

- The auxiliary lube oil pump can be switched off manually
- Optional it can be selected if the auxiliary lube oil pump remains switched on after T4 (re-lubricating time) has elapsed.

D 5.7 Trip of ETG

If

- a signal causing a trip is active

The expansion turbine control system triggers the following actions:

- A trip is indicated
- The solenoid valve SV G102 is de-energized and trip valve FV G102 is closed
- The generator is disconnected from grid
- The auxiliary lube oil pump will be switched on and remains interlocked on for the duration of T4.
- The start-up solenoid valve SV G103 de-energizes. If the start up valve FV G103 was open it closes.
- Stop signal to W505E is triggered and start up valve is closed if it has not already been reset (with GENERATOR MCB CLOSED plus 120 seconds elapsed).
- Ramp 2 is set to 0%. The nozzles of both stages close.
- The solenoid valve SV G104 de-energizes and nozzles stage 1 close.
- The digital output EXCITER OFF energizes. The digital output EXCITER ON de-energizes. The excitation voltage of the generator will be switched off.

The generator must be disconnected from grid (generator circuit breaker must open) with a time delay of maximum 1 second. If the generator is disconnected from the grid and the generator circuit breaker is open, the MCC will de-energize the signal GENERATOR CIRCUIT BREAKER CLOSED

In addition the expansion turbine control system will trigger the actions described in "SOFT STOP of ETG". If the trip condition has been deleted the trip can be reset via HMI.

The flow to process is secured by bypass valve FV G113 and bypass flap FV G112:

- Bypass valve FV G113 is set to calculated value of polygon function 2.
- Bypass flap FV G112 is opened with trip signal of ETG.
- Ramp 3 is ramped from calculated value to 100% and will release bypass pressure controller.

D 5.8 Operation during Winter



We recommend that you protect your plant against frost. Any required trace heater for water pipes, measuring pipes, instruments etc. must be installed by the customer.

D 6 Shut-down for a longer period of time

If it is planned to shut down the turbomachine plant for a longer period of time, please observe instructions for normal shut-down and for conservation.

Drain and flush the plant.

CAUTION All safety and warning devices have to be in proper operation if process pipes are pressurized with process gas during stand still. The seal gas and noise hood ventilation also have to be in operation.

D 6.1 Standstill operation

The lubricating system must be turned on for about 30 min once a week to cover all components with oil that need lubrication.

Starting the lubricating system has to be carried out in the following order:

Oil temperature	> 20 °C
Oil demister	ON
Seal gas system (if existing)	ON
Oil cooler	ON
Oil pump	ON

The panel heater and panel climate control unit (if equipped) must be switched on.



Treat electric machines as per manufacturer's instructions, i.e. energize the standstill heating.

The pipes for leakage gas must be heated during stand still if ambient temperature is below 0 °C.

Check the plant for damage by corrosion every six months.

CAUTION In plants erected outdoors, the oil heating and the auxiliary oil pump remain in operation during winter.

Drain water from all pipes and pressure vessels containing water. The same applies to condensate.



Additional and individual measures, specific to your plant, have to be agreed upon with Atlas Copco Parts & Service Center.

If you do not intend to re-commission the turbomachinery plant and still do not want to dismantle it, please contact the Atlas Copco Parts & Service Center.

D 7 Possible faults, causes and correction

Various trip functions are provided in the turbomachine plant. In the event of any of the trip criteria being exceeded in the respective direction, the machine is shut down automatically.

Several instrument points are equipped to actuate an alarm signal in advance of the trip point being reached. This permits early recognition of an imminent fault condition or malfunction, making it possible in many instances to intervene positively in the control process and restore the turbomachine plant to normal operating conditions and thus avoid shutdown.

Additional help is afforded by the following troubleshooting chart, which assists quick and reliable location of the cause of turbomachine tripping and any defective parts. Beyond that, the originally stable operation of the turbomachine might change due to other, external influences. In such an instance, vibration measurements should be made immediately. This often enables the cause of vibration to be ascertained in its early phase, this again preventing the occurrences of any more serious damage to the machine.



Before taking any action for remedy check the whole measuring circuit to ensure that the fault indication is correct.



Depending on the scope of supply some of the following items are not installed in your machine.



Danger by automatic start-up, and dangerous gases.

May lead to lethal injuries.

Removal of faults only after the machine has been stopped and secured against restart.

In the case of machines with toxic, explosive or suffocating process gas, sufficient safety measures must be taken for the protection of persons before carrying out maintenance work, such as

- flushing with ambient air or nitrogen in case of explosive gas
- shutting off the pipes to the turbomachine.

Fault	Possible cause	Elimination	By *)	Note
*) AC = AC staff	B = expert customer staff	W = maintenance staff		
Oil pressure too low	Oil temperature too high		B	See "Oil temperature too high"
	Oil filter fouled	Replace filter cartridge	W	Change over oil filter before (if dual filter is installed)
	Leaky oil pipe	Eliminate leakage	W	
	Use of wrong oil	Use specified oil	W	
	Spill valve defective	Replace spill valve	B	
	Oil pump failed	Clean and repair pump	B	
	Excessive bearing clearance	Replace bearing	AC	
Oil temperature too high	Water throughput too low	Increase oil cooler water throughput or clean cooler	B	Only possible, if oil cooler is water-cooled
	Change in water supply temperature	Increase water flow rate to oil cooler. If unsuccessful, inspect oil cooler	W	
	Cooling water controller defective	Repair or replace controller.	W	If applicable
	Temperature control valve defective	Replace temperature control valve	W	
	Cooler fan defective	Check fan	W	Only possible if oil cooler is air-cooled
Oil level in tank too low	Leaky oil pipe	Check all pipes, eliminate leakage	W	
	Oil cooler defective	Remove cooler bundle, if possible, and pressure-test	W	Only if oil cooler is water-cooled
		Replace oil cooler	W	

Fault	Possible cause	Elimination	By *)	Note
*) AC = AC staff B = expert customer staff W = maintenance staff				
Bearing temperature too high	Oil system incorrect	Check oil system	W	
	Bearing damaged	Remove and replace bearing	AC	
Vibration and noise level too high	Foundation vibrating	Foundation calculation to be checked	-	Contact AC / Engineering company
	Bearings damaged	Remove bearings and install spare bearings	AC	
	Generator/plant misaligned	Check foundation. Then re-align generator and plant.	AC	
	Nozzles damaged	Replace nozzle ring	AC	
	Nozzle loading mechanism defective	Replace springs in nozzle loading mechanism, replace radial sealing ring, if necessary	AC	
	Coupling worn	Replace wear parts	W	
	Coupling misaligned	Re-align coupling	AC	
	-	Vibration analysis, determine frequency and amplitude	AC	

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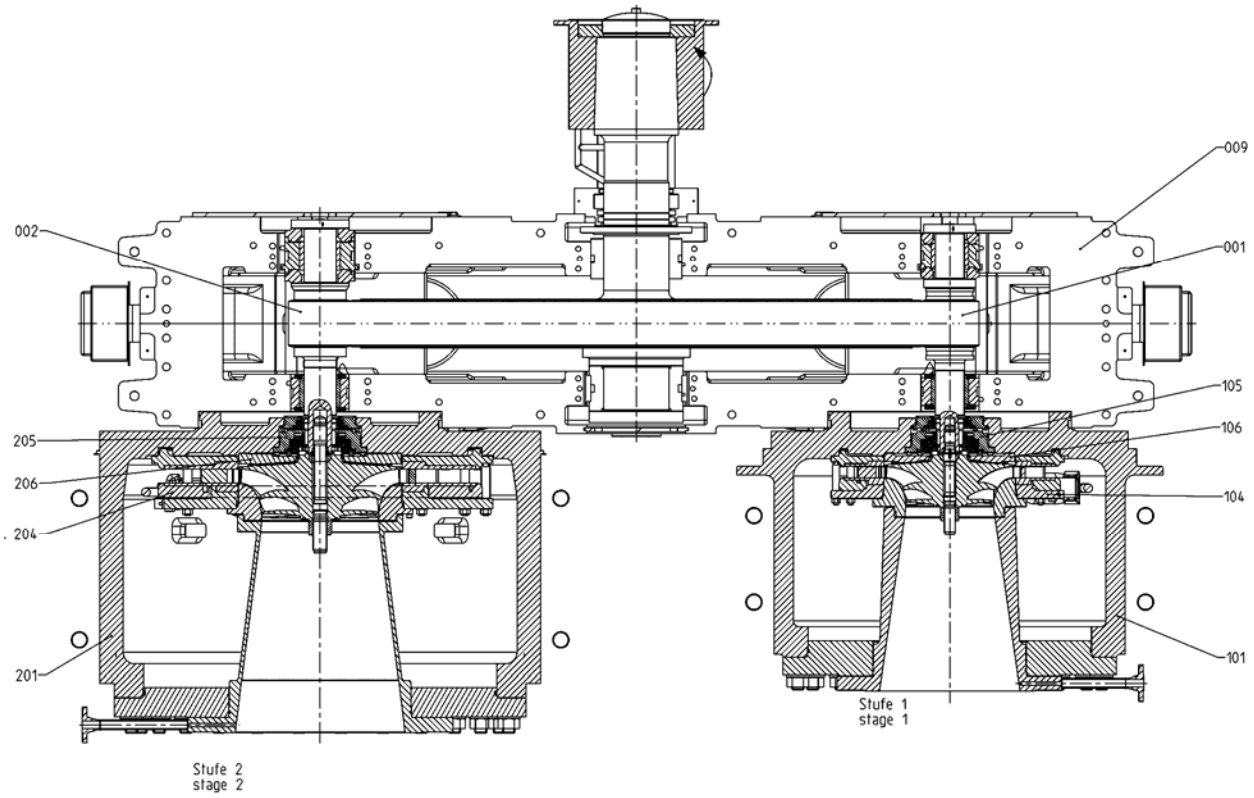
E 1 Turbine execution

The turbomachine unit consists of one or more expansion stages fastened to a gear box.

The turbine casings and the impellers overhang the gear box. The generator is connected to the gear via coupling.

Process gas enters the turbine by the inlet line. From there it is led to the nozzle ring equipped with movable nozzle blades which are provided to control throughput of gas through the turbine.

Kinetic power and cold are generated in the turbine. This power is used to power a generator.



00Y	Pinion shaft	X05	Shaft seal
009	Gear	X06	Impeller seal
X01	Casing assembly (compressor/turbine)	X =	Stage number
X04	Nozzle Ring	Y =	Rotor number

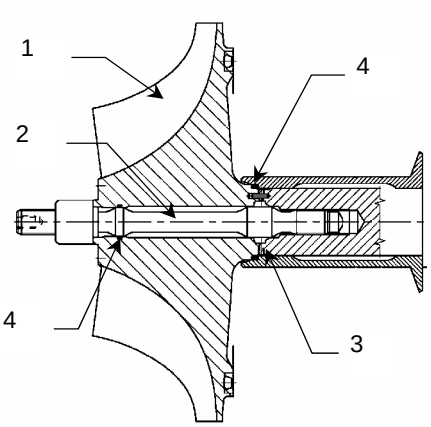
Expander casing

The barrel type expander casing encloses the impeller and includes the nozzle ring with loading device and the diffuser unit.

The expander casing is also connected to the gearbox using an adapter piece and an insulating plate. The axial position of casing to impeller can be modified by means of shims.

E 1.1 Rotor

The rotor consists of one or two overhang impellers and the compressor shaft, which is also the gear pinion shaft.



1 Impeller
2 Tension tie bolt / straining screw
3 Hirth serration
4 O-Ring

The Impeller and shaft are connected by means of a positive-lock selfcentering Hirth serration.

They are fastened by a hydraulically tensioned tie bolt or an impeller straining screw. A locating pin ensures identical position of impeller to shaft at all times.

The sealing of the impeller is effected by the use of O-rings.

The impeller

Impellers are cast or milled from high-quality materials. Radial impellers are manufactured with different angles of the blades and equipped either with or without shroud depending on aerodynamic requirements.

Impeller balancing

Each impeller is dynamically balanced at low speed in two planes. Compensation of weight is effected at the balancing planes provided on the impeller.

After balancing, the impeller is subjected to an overspeed test to give evidence of its strength. The dimensional check effected before and after overspeeding and the subsequent crack test show that the impeller has received occurred turbo force loads without problems.

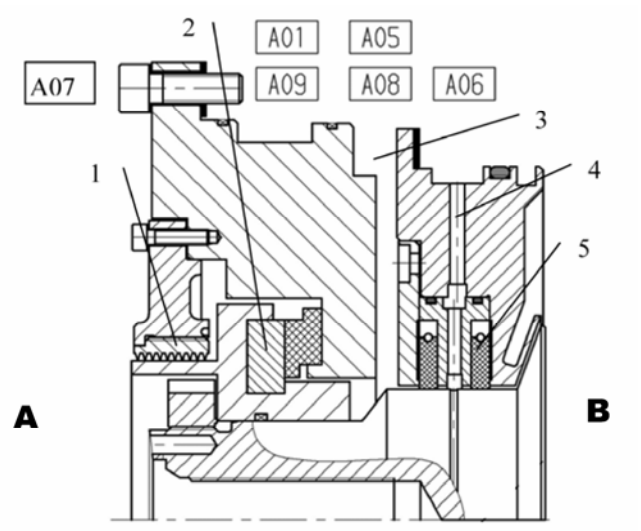
Shaft seals

In this compressor a combination of labyrinth seal, floating carbon ring seal and dry-face mechanical seal is employed as shaft seal.

The double-acting, dry-face mechanical gas seal itself consists of stationary, but axially movable spring-loaded carbon rings and rotating mating rings. This seal works like a gas-lubricated axial bearing. Spiral grooves in the rotating ring pump gas between the sliding surfaces which results in gas pressure building up. This, in turn, leads to the formation of a very narrow gap between the sliding rings.

There are two floating carbon rings at the gear side of the dry-face mechanical gas seal.

All components which make up the shaft seal are arranged in a casing. The arrangement of these components is as follows, starting from impeller rear:



1 Labyrinth ring
2 Pair of slide rings
3 Leakage gas chamber leading to safe location
4 Seal gas chamber for process gas
5 2 carbon rings
A Compressor side
B Gear side

For optimum operation reliability and safety, the seal requires absolutely clean gas or the use of filtered seal gas.

For further information about seal gas connections refer to P&I diagramm and sectional drawing

E 1.2 Trip valve, start up valve

Trip valve (Quick shut-down valve) and the parallel working start up valve are itegrated in the inlet piping.

E 1.3 Nozzle ring

The adjustable nozzles arranged on the turbine side are designed for a gradual control of the gas flow. An actuator acts on the single nozzles of the nozzle ring via a lever system and carrier ring.

E 1.4 Gear

A single helical spur gear is used to transfer power and reach operating speed. The gear consists of an oil-tight casing, horizontally split, in which the bull wheel shaft with teeth and the pinion shafts are arranged. The impellers are arranged in an overhung position on the pinion shafts.

Bearings and teeth are lubricated by pressurized oil. Bearing design allows the measuring of temperatures in the bearing.

The single stage casings are fastened on the gear. Inspection and maintenance work on the gear is feasible without dismantling the stages, as the gear cover can be lifted separately.



For further information refer to manufacturers documentation in the annex.

Driving shaft

The gear driving shaft is borne in tapered land bearings with the fixed bearing designed as combined radial/axial bearing.

The floating bearing is designed as a radial tapered land bearing. Bearings are horizontally split.

High-speed rotors

High-speed rotors are borne in radial tilting pad bearings. Axial bearings are not required, as axial force is received by thrust collars, from where it is passed on the low-speed driving shaft and its axial bearings.

These bearings are lubricated, feeding each tilting pad with the amount of pressurized oil required to insure bearing capacity and bearing heat transfer via oil spray nozzles.

The oil is conducted to the bearings by the lubricating system via separate oil feed lines of the gear.

E 1.5 Coupling

The coupling is designed as multiple-disk steel coupling with intermediate shaft. It is torsionally rigid and transfers the torque free of torsional clearances. The elastic multiple-disks made of stainless spring steel enable operation free of wear and maintenance even with inevitable shaft displacement.

Using the intermediate shaft, the coupling can be removed without having to alter the basic alignment of shafts or other main driving components.

For drawing, refer to annex.

E 2 Plant components



For location of the components see layout plan in the annex.



Read manufacturer's operating manual which includes instructions on installation, operation and maintenance.

E 2.1 Supporting structure

Foundation

For specification see foundation plan. The foundation must be designed in a way that:

- vibrations originating from the surroundings, e.g. from other machinery, must not be transmitted to the turbomachine
- vibrations of the foundation, resonant with turbomachine speed must not occur.

Information regarding the means for anchoring of the turbomachine are given on the foundation plan. This is effected by grouting of anchors or anchor bolts. For plant parts such as coolers, oil supply system and other secondary aggregates plugs are used frequently.

The contractor in charge of construction of the foundation shall bear full responsibility for the completion, adherence to dimensions, stability and vibration properties well matched to the machine.

E 2.2 Lubricating system

The lubricating system supplies all bearings, gear teeth and the driver/generator, if required, with the oil required for lubricating and cooling purposes.

The lubricating loop starts in the oil reservoir, from which pumps draw in oil and deliver it to the lubricating places, via cooler and oil filter. From there, heated lubricating oil is returned to the reservoir without pressure.

The lubricating system consists of the following main components:

Oil reservoir

The oil reservoir consists of welded steel sheets. It is provided with an opening for inspection and cleaning of all internal surfaces.

The drain valve arranged at the lowest point of the vessel bottom is designed to drain the reservoir. This must always be done if cooling or condensation water has entered the lubricating system. Prior to compressor start-up, it must be opened briefly to drain water, if any. The oil reservoir is equipped with an electrical heater.

Oil pumps The oil pumps deliver the oil to the consumers. They operate at the pressure stated in the operating data sheet.

Electric driven pump The oil pump is driven by an electric motor via a coupling. This electric motor is designed in a way that it is not overloaded when using specified oils.

Gear pump The oil pump is directly driven by the gear. For this purpose, it is flanged to the gear. It is driven by a separate set of wheels directly from the driving shaft.

Oil strainer/sieve An oil strainer or sieve located on the suction side of the oil pump protects against entry of coarse material.

Oil cooler The lubricating oil, which is heated by the mechanical losses of the turbomachinery plant and oil pump power, is cooled within the oil cooler assembly.

The oil cooler is designed as horizontal single or dual oil cooler (oil around tubes) equipped with a retractable bundle.

The oil cooler is equipped with oil and water-side connections for draining or venting purposes.

Dual oil filter The oil is cleaned in the dual oil filter. Solid matter carried in the oil is retained. The dual filter consists of two filter casings with replaceable cartridges and a two-stage switch-over device for continuous operation free of surges.

Oil demister with fan or eductor The oil demister is arranged on top of the oil reservoir. The oil demister for the oil reservoir is provided with several demister cartridges. The oily leakage gas coming from the oil reservoir is cleaned by means of a highly efficient filter system and subsequently conducted to the atmosphere. The filtered oil is returned to the oil reservoir.

Oil system piping

Oil system piping is designed in a way that maximum suction side oil velocities of W = 0.8 m/s and discharge-side oil velocities of W = 3.0 to 4.0 m/s are not exceeded. Pipes downstream of the filter are made of stainless steel.

All other pipes, including drain and vent pipes, are made with sight glasses and shut-off valves, as shown in the P+I diagram.

Piping is designed in a way that the oil pumps draw in oil directly from the oil reservoir. Non-return valves are used to prevent back-flow of supplied oil.

If the oil system is equipped with two oil pumps, the non-return valves in conjunction with the design of the pipe work, insure the filling of the suction pipe of the non-working pump.

E 2.3 Process gas pipes with accessory

Process gas pipes are conducted in a way that space is saved and the gas flow is influenced favourably to reduce losses. The type of pipe connection is shown in the layout plan (general arrangement plan).

Inlet strainer of the process gas inlet pipes

Permanent inlet strainers are installed at the inlet of the turbomachine to protect it against larger dirt particles entering it from the process pipes. Blinding of the inlet strainers is monitored by measuring the differential pressure across the strainers.

Safety valves

Safety valves are designed to protect plant parts against damage caused by overpressure. Valves employed in the turbomachinery plant are spring-loaded. For their structure and description, refer to the annex.

E 2.4 Factory test run

Quality Assurance of the final product is defined as functional test of the individual machine in the framework of a test run.

E 2.4.1 Mechanical test run

As a rule, mechanical test runs are carried out without testing performance data; in the course of compressor testing, the electric motor of the test shop is employed as driver, unless the original driving unit is to be tested concurrently.

In the course of this test run, the mechanical behaviour of the individual machine is evaluated under operating speed conditions.

E 3 Control systems/ interlocks

The descriptions included in this chapter are only designed for a better understanding of the control systems/interlocks. The documents on instrumentation and control systems are the sole binding documentation for the structure of the control system.

Extract from "Functional description"
Rev. 2 (dated 2011-09-14)
by C. Banik

E 3.1 Auxiliary Devices and Associated Systems

E 3.1.1 General Information

Prior to ETG start all auxiliary units need to be released from the HMI of the ACE expansion turbine control PC. To release or block the auxiliary devices press the corresponding function key on the monitor page “Auxiliary devices”. During normal stand still of the ETG the auxiliary devices should be released.

On the expansion turbine control cabinet the operation mode can be selected between LOCAL and REMOTE via selector switch.

If LOCAL is selected:

- the aux. devices can be started and stopped by pushing the related function key on the LCP
- ETG START can only be triggered from the expansion turbine control cabinet
- ETG STOP can be triggered from the expansion turbine control panel
- the HMI and LCP will indicate “OPERATING MODE LOCAL”

If REMOTE is selected

- the aux. devices can be started and stopped via PC.
- ETG START can only be triggered from the expansion turbine control cabinet
- ETG STOP can be triggered from the expansion turbine control panel
- the HMI will indicate “OPERATING MODE REMOTE”

In the control cabinet a LOCAL / REMOTE selector switch is installed. During normal operation these switch must be set to REMOTE. The logic of the aux. devices is always active when the aux. devices are released (e.g. low oil pressure during operation will start aux. lube oil pump) and is NOT deactivated if selector switch is set to LOCAL.

E 3.1.2 Oil Reservoir Heating

The oil reservoir is equipped with an electrical lube oil reservoir heater. The heater is equipped with a two point controller (bimetal contact TC G200) .The reference variable of the controller is set at 48°C (adjusted during commissioning). The temperature controller opens or closes a contact indicating the expansion turbine control system to trigger a signal to the MCC to switch the heater on or off.

If the auxiliary units are released the lube oil reservoir heating is automatically activated and the indication on HMI changes from “LOCKED” to “READY / ON”.

“LOCKED” means the oil reservoir heating is interlocked off. “READY” means the temperature control is activated and the heaters are ready for operation. “ON” means the heater is switched on.

If the auxilliary systems are released the lube oil reservoir heating can be manually activated and deactivated from the HMI. If the heating is manually deactivated the indication on the HMI changes from “READY / ON” to “OFF”. The signal to the MCC to switch the heater on / off will de-energize.

The oil reservoir heater is equipped with a safety thermostat (TSH G200). It has been firmly set to 80 °C and must be reset locally at the heater in case of interference. After the interference has been eliminated, the respective oil reservoir heater must be restarted manually from the HMI.

Plant Status (Cause)	**Tasks of control system/interlocks (Effect)**
– aux. devices not released OR – temperature limiter oil heater has been triggered TSHH (set at 80°C) OR – level lube oil reservoir is <LAL	– Oil reservoir heating is interlocked (OFF) – On the HMI the status for the oil heaters will indicate “LOCKED”
– oil reservoir heating is switched OFF from the HMI	– Oil reservoir heating is deactivated – On the HMI the status for the oil heaters will indicate “OFF”

– aux. devices released AND – the oil heating is activated AND – the temperature at lube oil reservoir heater drops below its reference value	– The temperature controller will close its contact indicating the expansion turbine control system to switch the heater on. – For the oil heater the indication on the HMI will change from “READY” to “ON”. – For the heater the output signal OIL HEATER COMMAND ON is triggered. The oil heater will be switched on.
– aux. devices released AND – the oil heating is activated AND – the temperature at lube oil reservoir heater rises above its reference variable plus an offset of approx. 3°C	– The temperature controller will open its contact indicating the expansion turbine control system to switch the heater off. – For the oil heater the indication on the HMI will change from “ON” to “READY”. – For the heater the output signal OIL HEATER COMMAND OFF is triggered. The oil heater will be switched off.
– signal OIL HEATER E-FAULT is active	– Alarm will be indicated on the HMI of the expansion turbine control cabinet – The indication for the oil heater on the HMI will change to “FAILURE”.

E 3.1.3 Auxiliary Lube Oil Pump P408

For lube oil supply for the ETG during start up, coast down and re-lubrication an electric driven auxiliary lube oil pump is installed.

The auxiliary lube oil pump can be started and stopped from the HMI (REMOTE) or LCP (LOCAL).

To test the auxiliary lube oil pump while the main oil pump is in operation, it is possible to switch the auxiliary lube oil pump manually ON/OFF for a short moment (if non of a.m. interlock is active).



Parallel operation of both oil pumps over a longer time is not permitted.

Plant Status (Cause)	Tasks of control system/interlocks (Effect)
– auxiliary devices not released	– The auxiliary lube oil pump is interlocked (OFF) – On the HMI the status for the auxiliary oil pump will indicate “LOCKED”
– ETG is not running, verified by position limit switch closed trip valve is energized AND – position limit switch closed start up valve is energized	– The auxiliary lube oil pump can be started and stopped from LCP or HMI (if pressure separation gas is above PAL and flow seal gas stage 1 and 2 is above FAL)
– pressure separation gas is below PAL AND – the coast down time T3 is active AND – re-lubricating time T4 is active	– The aux. lube oil pump remains switched ON for the duration of the coast down time T3. After the coast down time T3 has elapsed the aux. oil pump is switched OFF and remains interlocked OFF. On the HMI the status for the auxiliary oil pump will indicate “LOCKED” – If the pressure separation gas or flow seal gas of stage 1 and 2 rise above the low alarm setting during re-lubrication time T4, the aux. lube oil pump is switched ON and remains ON for the rest of the re-lubrication time T4.
– pressure separation gas is below PAL AND – re-lubricating time T4 has elapsed	– The aux. lube oil pump is switched OFF and remains interlocked OFF. – On the HMI the status for the auxiliary oil pump will indicate “LOCKED”
– ETG start is initiated	– The auxiliary lube oil pump is interlocked on – If T4 (re-lubricating time) was still active it will be reset with the ETG start signal.
– Generator circuit breaker is CLOSED	– The auxiliary lube oil pump will be switched OFF

– Pressure lube oil gear box inlet <PAL of one of the four pressure transmitters upstream gear box AND – ETG is running, verified by position limit switch closed trip valve is not energized OR – position limit switch closed start up valve is not energized	– The aux. lube oil pump is switched ON. – On the HMI the status for the auxiliary oil pump will indicate “RUNNING” – The pump keeps in operation until it is manually switched off or until the ETG is stopped / shut down and T4 (re-lubrication time) has elapsed.
– ETG is stopped or shut down	– The aux. lube oil pump is switched ON. – On the HMI the status for the auxiliary oil pump will indicate “RUNNING” – The pump will be interlocked ON until T4 (re-lubrication time) has elapsed.
– Aux. lube oil pump is in failure	– Alarm will be indicated on the HMI – On the HMI the status for the auxiliary oil pump will indicate “FAILURE”.

E 3.1.4 Emergency Oil Pump P409

In case of electrical power failure of the aux. lube oil pump during coast down or if low low alarm of lube oil transmitters upstream gear box (2oo3) is active, the emergency oil pump has been installed to supply cooling oil for the expander turbine and the generator during the coast down time T3. It is supplied by the emergency power system.

Plant Status (Cause)	**Tasks of control system/interlocks (Effect)**
– Auxiliary devices not released	– The emergency oil pump is interlocked OFF
– Lube oil pressure low low alarm (2oo3) upstream gear box is active. OR – aux. lube oil pump is in electrical failure during coast down time T3.	– The emergency oil pump will start automatically and will be interlocked ON for the coast down time. The expander is tripped. – If the aux. lube oil pump has been re-started during the coast down time T3 and the lube oil pressure upstream gear box is above PAL the emergency oil pump can be stopped manually from the LCP or HMI. Pump is stopped automatically when coast down time T3 has elapsed.
– Electrical failure emergency oil pump	– An alarm will be indicated

To test the emergency oil pump it can be manually started from the LCP or HMI during operation or stand still.



Parallel operation of the main lube oil pump or aux. lube oil pump and the emergency oil pump is permitted for short time only.

E 3.1.5 Oil Mist Separator Fan

The oil mist separator fan is installed at the oil reservoir.

Plant Status (Cause)	**Tasks of control system/interlocks (Effect)**
– auxiliary devices not released	– The oil mist separator fan is interlocked (OFF) – On the HMI the status for the oil mist separator fan will indicate “LOCKED”
– pressure separation gas is < PAL AND – the coast down time T3 is active AND – re-lubricating time T4 is active	– The oil mist separator fan remains switched ON for the duration of the coast down time T3. After the coast down time T3 has elapsed the aux. oil pump and the oil mist separator fan are switched OFF and remain interlocked OFF. On the HMI the status for the oil mist separator fan will indicate “LOCKED”. – If the pressure of the separation gas and the flow of the seal gas rises above the low alarm setting during re-lubrication time T4, the oil mist separator fan is switched ON for the rest of the re-lubricating time T4.
– pressure separation gas is < PAL AND – re-lubricating time T4 has elapsed	– The oil mist separator fan will be switched OFF and will remain interlocked off. – On the HMI the status for the oil mist separator fan will indicate “LOCKED”
– the auxiliary lube oil pump is on OR – ETG is on, verified by position limit switch closed trip valve is not energized OR – position limit switch closed start up valve is not energized	– The oil mist separator fan is interlocked on. – On the HMI the status for the oil mist separator fans will indicate “RUNNING”
– Oil mist separator fan is in failure	– Alarm will be indicated on the HMI – On the HMI the status for the oil mist separator fan will indicate “FAILURE”.

For test purpose the oil demister fan can be switched ON/OFF from the HMI or LCP (if non of a.m. interlock is active).

E 3.1.6 Solenoid Start Up Valve SV G103

During stop / shut down of the ETG the gas supply to the expansion turbine must be interrupted as quickly as possible. Therefore the start up valve is equipped with a solenoid for quick release.

Plant Status (Cause)	Tasks of control system/interlocks (Effect)
– ETG stop / shut down	– Solenoid valve de-energizes in case of trip for the duration of T3 (coast down time). In case of soft stop it de-energizes after ramp 1 is below 20% OR generator power is below 5%. In case of trip/ESD it de-energizes immediately. – When the solenoid is de-energized the instrument air supply to the valve actuator is cut off. The actuator will be relieved and moves to its fail position closed. The start up valve will close.
– T3 (coast down time) has elapsed	– Solenoid valve energizes

E 3.1.7 Solenoid Trip Valve SV G102

During stop and shut down of the ETG the gas supply to the expansion turbine must be interrupted as quickly as possible. Therefore the trip valve is equipped with a solenoid for quick release.

Plant Status (Cause)	Tasks of control system/interlocks (Effect)
– digital input GENERATOR CIRCUIT BREAKER CLOSED	– solenoid valve energizes and the trip valve opens. (opening time is adjusted via needle valve installed in the instrument air supply line)
– ETG stop / shut down	– Solenoid valve de-energizes immediately in case of trip. In case of soft stop it de-energizes after ramp 1 is below 20% OR generator power is below 5%. In case of trip/ESD it de-energizes immediately. When the solenoid of the trip valve is de-energized, the instrument air supply to the valve actuator is cut off. The actuator will be relieved and the trip valve moves to its fail position closed.

E 3.1.8 Solenoid for Nozzle Stage 1 SY G104

During stop / shut down of the ETG gas supply to the expansion turbine must be interrupted as quickly as possible. Therefore the expansion turbine inlet nozzles are equipped with solenoid for quick release.

Plant Status (Cause)	**Tasks of control system/interlocks (Effect)**
– ETG stop / shut down	– Solenoid valve nozzles stage 1 de-energizes in case of trip for the duration of T3 (coast down time). In case of soft stop it de-energizes after ramp 1 is below 20% OR generator power is below 5%. In case of trip/ESD it de-energizes immediately. – When the solenoid is de-energized, the instrument air supply to the nozzle actuator is cut off. The actuator will be relieved and move to their fail position closed. The inlet nozzles close to their MIN position.
– T3 (coast down time) has elapsed	– Solenoid valve nozzles stage 1 energizes

E 3.1.9 Space Heater Generator

To avoid condensation in the generator it is equipped with an electrical space heater.

The space heater should always remain switched on when the generator is not connected to the grid. Manual start and stop of the anti condensation heater is not possible.

E 3.1.10 Monitoring of start up valve and nozzle position

To monitor proper function of the position controllers (start up valve, expansion turbine inlet nozzle) the feedback of the position controller will be compared to its set point.

If the deviation between set point and feedback exceeds an adjustable value for an adjustable time, an alarm ZDAH will be indicated in the expansion turbine control system.

The deviation (approx. 5%) and the time delay time (approx. 10sec) will be adjusted separately for each position controller during commissioning.

E 4 Controller

Extract from "Functional description"
Rev. 2 (dated 2011-09-14)
by C. Banik

E 4.1 Process controller of expanders: outlet pressure controller PIC G109

Due to process related reasons the expander outlet pressure is controlled.

This will be achieved by the outlet pressure controller PIC G109. Its task is to control the outlet pressure PT G109 by acting on both expansion turbine inlet nozzles. As process controller PIC G109 is always active during normal operation. The controller can be switched from AUTO to MAN by operator (not password protected). The controller output variable m can be set to a desired value. During start-up controller should remain in AUTO. The final adjustment of the controller (e.g. proportional action or integral action coefficient) is password protected and will be done by Atlas Copco during commissioning.

The controlled value X of the outlet pressure controller PIC G109 is stage 2 expander outlet pressure PT G109.

The reference variable W = 3,5 bar(g) is adjustable within certain limits (W-L = 3,5 bar(g),

W-H = 4,1 bar(g)).

The output variable m of the outlet pressure controller PIC G109 is connected to MIN Selection 2. There it will be compared to the output of ramp 2 and to the control output variable from expander power limit controller IIC G160 to both expansion turbine inlet nozzles (FV G104, stage 1 and FV G107, stage 2).

The lowest value will be transferred via nozzle calculation function 1 to the inlet nozzles of stage 1 and via polygon function 1 which distributes the position signal to the expansion turbine inlet nozzles stage 2.

The outlet pressure controller compares W and X with the difference being the control error

W – X.

A negative control error (W < X) results in a decreasing controller output variable, (both expansion turbine inlet nozzles close).

A positive control error (W > X) results in an increasing controller output variable, (both expansion turbine inlet nozzles open).

E 4.2 Process controller of bypass: Bypass pressure controller PIC G113

Due to process related reasons the bypass valve pressure controller will control pressure to process in case of ETG trip or during ETG standstill.

PIC G113 is acting on bypass valve FV G113 via reverse function due to it's fail safe position open (4mA = 100% open = 0% closed). As process controller PIC G113 is always released via ramp 3 during ETB standstill. Controller output variable is reduced to 0% by ramp 3, if generator has connected successfully to grid. FV G112 will close (verified by limit switch) when ramp 3 has reached 0%. This ensures a smooth transfer from bypass operation to ETG operation.

During operation controller output (bypass opening) is always set to a value corresponding to ETG load, calculated by polygon function 2 if an ETG trip is triggered. In case of ETG trip, FV G113 is already open and flap FV G112 will open immediately to ensure flow to process.

During normal stop (Soft stop) and after an adj. time elapsed (Time until positioner FV G113 reached 0% after soft stop), bypass pressure controller is released by ramp 2 and flap FV G113 will also open. This ensures a smooth transfer from ETG operation to bypass operation.

The controller can be switched from AUTO to MAN by operator (not password protected). The controller output variable m can be set to a desired value. During start-up controller should remain in AUTO. The final adjustment of the controller (e.g. proportional action or integral action coefficient) is password protected and will be done by Atlas Copco during commissioning.

The controlled value X of the bypass pressure controller PIC G113 is pressure PT G109.

The reference variable W = 3,5 bar(g) is adjustable within certain limits (W-L = 3,5 bar(g),

W-H = 4,1 bar(g)).

The output variable m of the bypass pressure controller PIC G113 is connected via reverse function to bypass valve FV G113.

The bypass pressure controller compares W and X with the difference being the control error

W – X.

A negative control error (W < X) results in a decreasing controller output variable, (bypass valve closes).

A positive control error (W > X) results in an increasing controller output variable, (bypass valve opens).

E 4.3 Generator Power Limit Controller IIC G160

To protect the ETG from damage, the maximum generated power must be limited to 16,2 MW.

This will be achieved by the generator power limit controller IIC G160. Its task is to limit the generated power by acting on both expansion turbine inlet nozzles. As the generator power limit controller is a safety controller, it is activated only at extreme operating conditions. It does not assume any control function during normal operation. The final adjustment of the controller is password protected and will be done by Atlas Copco during commissioning.

The controlled variable X of the power limit controller IIC G160 is the generated power of the generator. The reference variable W is a fixed value of 16,2 MW.

The output variable m of the power limit controller is connected to MIN Selection 2. There it will be compared to the output of ramp 2 and to the output variable from the outlet pressure controller PIC G109. The lowest value will be transferred via nozzle offset calculation 1 to the inlet nozzles of stage 1 and via polygon function 1 witch distributes the position signal to the expansion turbine inlet nozzles stage 2.

The power limit controller compares W and X with the difference being the control error W - X.

A negative control error (W < X) results in a decreasing controller output variable, (the expansion turbine inlet nozzles close).

A positive control error (W > X) results in an increasing controller output variable, (the expansion turbine inlet nozzles open).

Change between the controller operating modes AUTO/MANUAL is password protected. If controller is set to MAN during standstill, ramp 2 is triggered to run to 0%. When controller is set back to AUTO ramp 2 return to normal operation.

E 4.4 Synchronizing Controller SIC G160 by Woodward W505E

The synchronizing controller SIC G160 implemented in Woodward W505E is used to control the speed during ETG start up and synchronisation of the generator. The final adjustment of the controller is password protected and will be done by Atlas Copco during commissioning. For detailed information refer to Woodward W505E operating guide.

The controlled variable X of the controller SIC G160 is the actual speed of the bull gear magnetic pick up SE G150.A and SE G150.B. For signal exchange refer to ACE circuit diagram (ACE Doc. No.: 6970 423 425) for W505 Governor. After start, W505E will increase speed with 50 RPM/s to synchronize speed of 1500 RPM/s. During synchronisation the automatic synchronizer sends two digital signals to the Woodward 505E in the expansion turbine control panel which cause the set point of the sync controller SIC G160 to increase and decrease the set point between 1450RPM and 1550RPM in steps of 5RPM. The output of the sync controller is acting on the start up valve.

When the machine is connected to the grid and during normal operation the sync controller is not active and its output is forced to 0. After a successful start (GENERATOR CIRCUIT BREAKER has closed) the start up valve is closed with a time delay of approx. 120 seconds by W505E.

E 4.5 Ramp 1

If

- the generator is synchronized and connected to the grid, verified by digital input GENERATOR CIRCUIT BREAKER CLOSED

Ramp 1 is triggered and its output value ramps from 0% to 100%

If

- the ETG soft stop button has been pressed AND ramp 3 has reached 100% OR generator power is below 15%

OR

- The ETG is shut down

Ramp 1 is triggered and its output value ramps from the actual value to 0%

The ramp 1 releases the output signal via MIN selection 2 of the power limit controller IIC G160 and the process controller PIC G109 to the inlet nozzles. Ramp up and down rates are password protected and will be adjusted during commissioning.

E 4.6 Ramp 2

If

- the generator is synchronized and connected to the grid, verified by digital input GENERATOR CIRCUIT BREAKER CLOSED

Ramp 2 is triggered and its output value ramps from 100% to 0%

If

- the ETG soft stop button has been pressed

AND

- the time until FV G113 reached 0% after soft stop has elapsed

Ramp 2 is triggered and its output value ramps from the actual value to 100%

OR

- If ETG is tripped, ramp 2 is set to a calculated value of polygon function 2 and is ramped to 100%

The ramp 2 releases the output variable m via m-H clamp of the bypass pressure controller PIC G113. Ramp up and down rates are password protected and will be adjusted during commissioning.

E 4.7 Polygon Expansion Turbine Inlet Nozzles

The polygon function 1 is used to provide the possibility for asynchronous operation of the expansion turbine inlet nozzles stage 1 and stage 2. Depending on the polygon setting the relation of the output signal to the expansion turbine inlet nozzle stage 1 and stage 2 will change accordingly. The setting of the polygon function is password protected (final adjustment during commission).

For bk min nozzle adjustments refer to ACE Doc. No.: 6970 423 420

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F 1 Ambient conditions

The turbomachinery plant was designed for the following ambient conditions:

F 1.1 Temperature

Ambient temperature:	Outdoors	Indoors	
min.	5		°C
max.	48		°C

F 1.2 Installation of turbomachine

All foundation loads are indicated on the foundation plan/ outline plan.

Component \ Installation	Outdoors	Indoors	with roof	in noise hoode	with forced ventilation	with heating	Hazardous area	
Turbomachine	X							
Oil system	X							
Generator	X							

F 2 Supply connections, electricity and auxiliary materials

For further information about electrical connections refer to circuit diagram in the annex.

For dimensions of pipe connections refer to P + I diagram and layout plan/outline plan.

F 2.1 Electric energy for:

Energy per turbomachine unit

Component	no. per unit	Voltage V	Power/ total kW	Phase	Frequency Hz
Lubricating oil pump motor (AC)	1	415	30	3	50
Lubricating oil pump motor (DC)	1	110	19	DC	-
Oil heater	1	415	3.75	3	50
Oil mist separator	1	415	0.75	3	50
Control Cabinet				1	
Space heater generator	1	240	2.8	1	50
PLC unit (turboexpander control) UPS		240 UPS	2	1	50
Cabinet lightning (turboexpander control)		240	2	1	50
Control cabinet (generator control) - UPS		240 UPS	2	1	50
Cabinet lightning (generator control)		240	2	1	50

F 2.2 Cooling water supply

Consumption, complete		116	m^3/h	Oil cooler, generator cooler
Inlet pressure	norm.	5	bar(g)	
	max.	12	bar(g)	
Inlet temperature		38	°C	
Fouling factor	max.	$0.34 \cdot 10^{-3}$	m^2K/W	

F 2.3 Instrument air and seal gas

Seal and flushing gases must meet the following requirements regarding particle size:

3 µm

Instrument air per unit

Pressure	min.	6	bar(g)	
	max.	7.9		
Dew point			°C	
Consumption actuators		35	Nm^3/h	total estimated, depends on control proceedings
Consumption generator purging before start up		410	Nm^3/h	for one hour
Consumption generator purging during operation		41	Nm^3/h	

Seal gas per unit

Type		N_2		
Pressure	norm.	3	bar(g)	
	max.	8		
Dew point			°C	
Consumption		55	Nm^3/h	

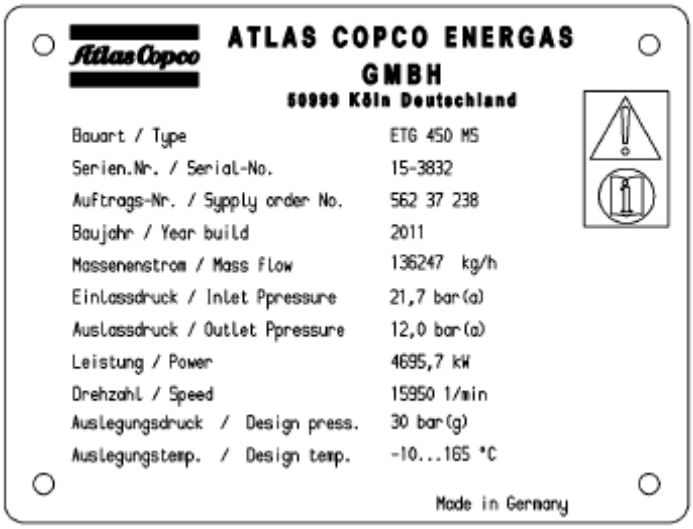
F 2.4 Oil filling

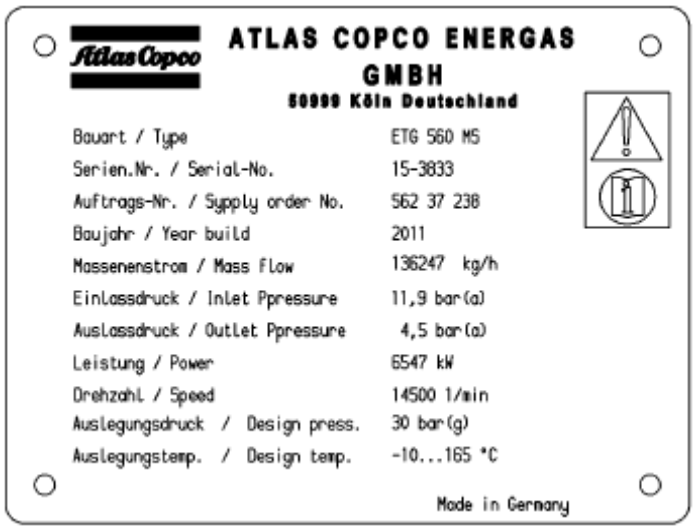
Quality	ISO VG 46		For recommended lubricants, refer to chapter "Works Standards" located in the annex .
Quantity filling	7 650	l	
Quantity filling per syphon	10	l	

Oil demister syphons have to be refilled every half year.

F 3 Machine data

F 3.1 Name plate





F 3.2 Turbine data

ET 01 ETG450MS

Operating case		**Nominal**		
Gas type		Syngas		
Molecular weight	kg/kmol	13.573		
Nozzle position	%	112.5		
Volumetric flow V_n (1,013 bar(a) 0 °C)	Nm^3/h	225 000		
Mass flow	kg/h	136247		
Inlet pressure	bar(a)	21.7		
Inlet temperature	°C	150		
Gap pressure	bar(a)	16.82		
Outlet pressure	bar(a)	12.0		
Outlet temperature	°C	124.29		
Turbine speed	min^{-1}	15 950		
Cold production	kW	4 695.7		
Coupling power	kW			

ET 02 ETG560MS

Operating case		**Nominal**		
Gas type		Syngas		
Molecular weight	kg/kmol	13.573		
Nozzle position	%	112.5		
Volumetric flow V_n (1,013 bar(a) 0 °C)	Nm^3/h	225 000		
Mass flow	kg/h	136247		
Inlet pressure	bar(a)	11.9		
Inlet temperature	°C	96		
Gap pressure	bar(a)	7.83		
Outlet pressure	bar(a)	4.5		
Outlet temperature	°C	20.42		
Turbine speed	min^{-1}	14 500		
Cold production	kW	6547		
Coupling power	kW			

F 3.3 Lubricating system

Operating point				
Oil pressure before turbomachinery	bar(g)	2.5		
Oil temperature before turbomachinery	°C	47		

F 3.4 Nominal generator data

Frequency	Hz	50
Voltage	V	6 600
Generator Power	kW	13 000
Nominal speed	min^{-1}	1 500

F 3.5 Sound level of turbo-machine plant

Operating point Turbine				
Mean acoustic power $\overline{L}_{WA}$ *)	dB(A)	120		
Emission level $\overline{L}_{pA}$ at work place, undamped *)	dB(A)	102		

*) Distance to measuring surface: 1 m
Sound data tolerance: ± 2 dB

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G 1 Safety precautions and work instructions

Please refer to chapter “Basic safety precautions”.

CAUTION Work on the turbomachine must never be carried out by unqualified personnel.

Staff performing maintenance, inspections and overhauls are obliged to read the following instructions and carefully review at the corresponding drawings and supplier documents to familiar with the equipment and the required techniques prior to working on turbomachines.

We recommend to have all maintenance carried out by AC personnel.

AC staff should also exchange spare parts even after the warranty period has expired to maintain the functional warranty applicable to the spare parts.



Danger by automatic start-up, and dangerous gases.

May lead to lethal injuries.

Maintenance works has to be done only after the machine has been stopped and secured against restart.

In the case of machines with toxic, explosive or suffocating process gas, sufficient safety measures must be taken for the protection of persons before carrying out maintenance work, such as

- flushing with ambient air or nitrogen in case of explosive gas
- shutting off the pipes to the turbomachine.



Increased Fire Hazard due to explosive process gases (e.g. O_2, H_2, CO, …)

Solvents and lubricants that are not approved for these process gases must not be used.

After assembly, maintenance or cleaning of the turbomachine, and prior to commissioning, all plant parts and accessories are to be purged with clean, dry gas. This gas must be of a type that does not react with the process gas. Therefore, it has to be ensured that all dust, rust, foreign particles, liquids and all contamination incompatible with the process gas have been removed.

Measuring instruments approved for this process gas must be used only!



Observe the official inspection intervals applicable to explosion protection equipment and devices. Also observe the national laws, rules and regulations valid in your country, refer also to manufacturer's documentation.

The plant user is responsible for erecting sufficient danger area signs.



Danger: suspended load/falling parts

May lead to severe injuries.

- Use only approved hoisting equipment and cranes of sufficient capacity. For information on weights refer to the foundation and layout plan, or information on packing.
- Employ special auxiliary equipment, e.g. traverses, loading joists, if specified.
- Use only undamaged ropes and chains.
- Protect the edges whenever hoisting chains or ropes are placed over edges of packing or machinery.
- Lifting eyelets are not always designed to receive the total weight. Pay attention to the information contained on their stickers.
- Secure parts against shifting during transport/handling.
- Observe the shift in center of gravity during transport.
- Refrain from standing below suspended loads.

Waste disposal

The turbomachine and plant components that have become unusable have to be duly disposed of at the end of their service life.



Oils and liquid gas components must never be drained into the ground or waste water systems. For this reason, any condensate which is e.g. discharged from the plant, must be collected in separating systems.

In this context, you should note the following:

- Used oils must never be mixed with other materials such as cleaning agents, solutions, and paints.
- Oil containing PCB and oils containing halogen must be collected separately from normally used oils, as they must be disposed of separately.
- Electrical and electronic devices have to be duly disposed.

G 2 Maintenance



For further information about maintenance schedule during operation, refer to chapter "Operating instructions".

For information on maintenance, refer to AC's and AC's sub-suppliers maintenance plans in Chapter "Records, forms and check lists" and "Technical documentation and instruction manuals of AC's sub-suppliers".

For maintenance procedures of the plant parts (lubricating system, cooling system, driver, ...) it is mandatory to follow the instructions of the manufacturer.

CAUTION The machine must be protected against corrosive atmosphere, especially during the following procedures and durations, respectively:

- during installation procedures
- during any interruption of the installation procedures
- during the maintenance procedures
- during any interruption of the maintenance procedures
- during the duration between the end of installation and first commissioning
- during the duration between the end of maintenance procedures and recommissioning

Refer to chapter "Preservation and protection against corrosion".

G 3 Inspection

Inspections are classified as follows:

- Oil inspection
- Minor inspection
- Major inspection
- Pressure equipment inspections

The turbomachine only requires to be shut down for the major inspection, which can be carried out either by the owner or by AC under a maintenance contract. Oil and minor inspection can be carried out while the equipment is running.



The first major inspection must always be carried out by Atlas Copco specialists in order to protect the owner's warranty rights.

The following maintenance intervals have to be adhered to.

CAUTION The maintenance intervals in chapter "Records, forms and check lists" and in AC's sub-suppliers documentation are binding and have to be adhered to.

Inspection procedure	Due period after 1st commissioning	Intervals
First oil inspection	200 hours	
Second and further oil inspections	1 year *)	every year *)
Minor inspection	According to AC specifications	
Major inspection	According to AC specifications	
Inspection of pressure equipment		in conformity with official intervals

*) For compressors of process gases, which may cause alterations of the oil, maintenance must be carried out in shorter intervals (every three months).

For turbomachines, which are frequently started and shut down, inspection intervals should be fixed as a function of an "Operating data analysis".

This analysis is based on performing a vibration analysis (to assess the mechanical behaviour of your turbomachine); and a thermodynamic analysis (efficiency calculations).

Based on this analysis, an improved planning of revisions, repairs and shutdown is possible.

Deviating from the schedule above, longer or shorter intervals might be allowed per individual application.

However, intervals between individual inspections should not exceed 24 months.

Depending on the prevailing plant or process conditions, deviations from this schedule should be determined in co-operation with our Service Department.

An inspection or maintenance contract tailored to the needs of your plant with our Service Department is recommended. This will optimize the plant operation over the long term.

G 3.1 Oil and oil filter inspection

Inspection of the oil can be undertaken by the owner's chemical laboratory, by the oil supplier's technical maintenance service or Atlas Copco (please contact our Service Department).

An oil sample (about 0.1 liter [3.5 oz]) should be taken during operation from the flow loop at a place upstream of the oil filter. Also provide a sample (about 0.1 liter [3.5 oz]) of new oil for comparison.

If the oil tested meets the specification requirements, no oil change is required.



Danger: Fire

Check that the oil heating is switched off during oil change. Otherwise severe overheating could damage the element and/or fire may occur.

CAUTION When working on the lubricating system, make sure that foreign particles (even dust) cannot enter the system.

When making oil inspections, the following additional operations must be carried out:

- Briefly open the block valves located at lowest point of oil reservoir and drain any condensate which has collected.
- Check the pollution degree of filter and change the polluted filter cartridge, if necessary. It is recommended to change the oil filter cartridges whenever oil changes are carried out.

Oil change

Take care that oil level is always between minimum and maximum during the oil change. Doing so will guarantee an uninterrupted oil supply of the turbomachine.



Consider the volume of the overhead tank, if applicable.

Changing of oil filter cartridges



Dual oil filters can be changed while the turbomachine is operating.



For information about installation, operation and maintenance refer to the manufacturer's operating manual in the Annex.

G 3.2 Oil filling

Quality	ISO VG 46		For recommended lubricants, refer to chapter "Works Standards" located in the annex .
Quantity filling	7 650	l	
Quantity filling per syphon	10	l	



Oil demister syphons have to be refilled every half year.

G 3.3 Minor inspection

This procedure is carried out while the turbo machine remains in operation. It is limited to reading the measurements which are to be entered in the operating data sheets.

Compare the readings obtained in every minor inspection with those initialy recorded at commissioning. Allowance must be made for any differences in suction conditions, cooling water inlet temperature (if applicable), etc..

If any high deviations are ascertained, the necessary action to correct them must be considered in accordance with the particulars given in chapter “Possible faults, causes and corrections”.

In addition, the plant must be checked for loose screws and parts and attention should also be given to abnormal noise and vibrations.

If the plant components you specified require shorter inspection intervals than those mentioned here, see respective sub-suppliers manuals.

G 3.4 Major inspection

The major inspection is a complete machine check-up, Clearances, fits and degree of wear and fouling will be evaluated on all major components.

A part of this inspection is carried out while the machine is running, part of it with machine shut down. The major inspection also includes all the tests of the minor inspection.

The following documents of the manual are required for this inspection:

- Data sheets
- Clearance and alignment records, if any
- Technical documentation of AC's sub-suppliers
- Works Standards
- Drawings

The following evaluations are performed:

Gearbox	Gear teeth	Teeth and contact pattern
	Axial bearings	Contact pattern and clearance
	Radial bearings	Contact pattern and clearance, replace, if necessary, check diameter
	Oil seal	Clearance, replace if necessary
	Shaft seal	Contact pattern, surface, clearances
	Axial shaft position and shaft vibration pick-up	Mounting, measuring clearance

The delivered gearing was designed for an unlimited service life, but slight wear of the tooth flank, which has a negligible effect on the service life, may occur.

Compressor	Adjustable guide vanes	Vanes, ease of adjustment and position, surface
	Suction nozzle	Surface
	Impeller	Inlet edges, surface cleanliness, concentricity with rotor shaft, crack-test
Driver	See manufacturers instructions	
Plant parts	See manufacturers instructions	

Coupling Dismantle spacer, check alignment. When a complete coupling must be replaced, the stand-by coupling must be balanced to G < 2.5. When single parts are replaced, these must be balanced to G < 1 (refer to ISO 1940).

CAUTION To disassemble a coupling hub with cylindrical/conical shrink fit, manufacturer`s operating instructions are mandatory. Refer to chapter annex and information in chapter tools.

Impeller Remove any deposits that have formed on the impeller by cleaning.

Check the impeller thoroughly for wear, corrosion, erosion or cracks. Any erosion of metal from the impeller might impair the balancing state of the entire rotor and thus lead to vibration problems. In this case, we recommend to re-balance the rotor group.

CAUTION Never use abrasives to clean bearing pads or shaft surfaces.

Shaft Check the bearing places of shafts for wear and cracks.

Any material deposit or discoloration that is detected here should be checked in detail.

Bearings The decisive factor for evaluating tilting pad bearings is not only the undamaged state of the running surfaces of the tilting pads. The bearing damage pattern resulting e.g. from impact loads is characterised by flattened pad "backs".

Undamaged "backs" of tilting pads are characterised by even, linear, mat stripes. Damaged tilting pads, however, stand out for distinct conical pressure marks which verify that the supporting bodies of the pads have been upset. Tilting pads "marked" such must be replaced, as these deformations will make the rotor unstable.

Vibration measuring places Also check the vibration measuring places of turbine shafts for scratches or indentations. Any shaft damage detected here will entail faulty indication of vibrations at the vibration monitor.

O-rings Replace only worn O-rings.

Shaft seals Inspect oil- and air-side shaft seals for wear, damage to the jointline and bent labyrinth tips. A slight wear of these seals is considered normal. If the shaft labyrinth tips (on the shaft) are undamaged and the wear is only slightly worn (less than 0.1 mm), the seal need not be replaced.

Also, the clearances must be checked against the assembly clearance drawing.

G 3.5 Pressure equipment inspections



May lead to severe injuries or death.

Pressure equipment and associated safety devices must not be manipulated.

Subsequent welding is absolutely prohibited.

The official inspection intervals applicable to pressurized components (pressure equipment) are to be observed. The national laws, rules and regulations valid in the country of erection, and the inspection intervals in the manufacturer's documentation are also to be observed.

G 4 Disassembly of components

While disassembling functional groups to check for satisfactory operation (e.g., surface condition such as cracks, wear, corrosion; adherence to dimensions, clearances, etc.), it is imperative to adhere to manufacturers' instructions, and to the instructions contained in the following sections.



Danger: suspended load/falling parts

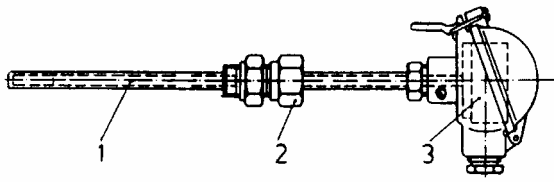
May lead to severe injuries.

- Use only approved hoisting equipment and cranes of sufficient capacity. For information on weights refer to the foundation and layout plan, or information on packing.
- Employ special auxiliary equipment, e.g. traverses, loading joists, if specified.
- Use only undamaged ropes and chains.
- Protect the edges whenever hoisting chains or ropes are placed over edges of packing or machinery.
- Lifting eyelets are not always designed to receive the total weight. Pay attention to the information contained on their stickers.
- Secure parts against shifting during transport/handling.
- Observe the shift in center of gravity during transport.
- Refrain from standing below suspended loads.

Danger: discharge of compressed gas

May lead to lethal injuries.

- Work must only be carried out when the machine is not in operation.
- Prior to doing any work on the turbomachine, safely block the suction and discharge pipe using a blind insert. Do not rely on block valves.
- For resistance thermometers without welded immersion tubes the protective tube of the thermometer (1) is directly subjected to the plant pressure. For removing the thermometer or measuring unit (3), the compression-type fitting (2) must only be loosened if the system is not pressurized, otherwise the whole thermometer will be catapulted out of the measuring place (for more information refer to sub-supplier's documentation in the annex).



Danger: electric voltage

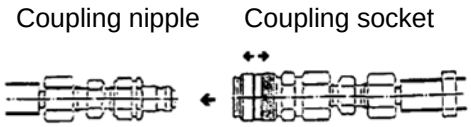
May lead to lethal injuries.

- Prior to working on electrical equipment, de-energize the plant.
- Work on power plants must only be carried out by expert personnel.
- When de-energizing units, do not forget auxiliary circuits, e.g. standstill heatings.
- Make sure to protect switches against re-activation when de-energizing units.
- Isolate or cover any adjacent life parts.

Danger: bursting coupling socket

May lead to severe injuries

- Prior to pressurizing the device, make sure that the outer coupling socket ring is correctly positioned. After coupling, this ring must be easily moveable to and fro. Faulty installation might cause the ring to burst, where the impending shrapnel could potentially cause severe injuries.
- This advice applies generally to all hydraulic connections of this kind.



G 4.1 Expander casing

Inspections of the expander stages only require disassembly of diffusor nozzle, connecting plate, mating contour, nozzle ring, impeller and shaft seal. The upper gearbox half must not be lifted for this purpose.

For disassembly use the mounting device described in chapter "Tools".

Handle the diffusor nozzle and connecting plate with extreme care as they are very heavy.

G 4.2 Impeller

The impeller must be removed whenever the impeller itself, the diffuser guide vanes or the pinion shaft have to be dismantled for inspections.

1. Prior to dismantling the impeller, support it carefully, because once you have removed the impeller nut the weight of the impeller must in no case be supported on the impeller tiebolt.

CAUTION Pinions equipped with Hirth-serration always have impeller tiebolts with right-handed thread.

2. Loosen the impeller nut by means of the hydraulic tensioning device that is supplied with the machine. Its accessories are shown in chapter „Tools“. Use only these components.
   For required pump pressure PV and part number AK of the correct hydraulic device refer to the rotor drawings.

For all work involving hydraulic tools, compliance with manufacturer’s instructions shown in chapter „Tools“ is mandatory.

3. Connect the required parts of the tensioning device as specified on the drawing.
4. Pressurize the hydraulic tool as specified and use a adjusting rod to turn the impeller nut to the left to loosen it.
5. Depressurize the hydraulic tool. After that, the impeller nut must still be easily turnable. If this is not the case, repeat step 4.
6. Take off the hydraulic tool.
7. Remove the impeller nut.
   Pull the impeller off the shaft.

To pull off heavy impellers (exceeding 30 kg) from the shaft, unscrew the impeller nut. Then, apply the lifting device, refer to Chapter "Tools", supplied for this purpose to the impeller hub surface. When pulling the impeller out, support the end of the lifting rod and apply counter-weights, if necessary.

When placing the impeller on the ground, make sure to not damage the Hirth-serration.

G 4.3 Gearbox cover

To expose gear parts such as bearings or oil seals for inspection, simply lift the upper gearbox casing half. Disassembly of a compressor stage is not required.

1. Separate the extension cables from all vibration pick-up cables on the gearbox cover and instruments that are fastened to the gearbox cover.
2. Tape the vibration pick-up cables to the gearbox cover.
3. Remove the coupling guard.
4. Unfasten all screws that hold the gearbox cover to the gearbox and remove both tapered pins.
5. Screw the four pulling screws into the gearbox cover flange and carefully separate gearbox cover and gearbox bottom.
6. Screw two stud bolts of about 300 mm length into two threaded bores that are arranged opposite one another to avoid a pendulum motion of the gearbox. This will reduce the potential for damage.
7. Lift the gearbox cover by means of a crane. Attach the ropes to the four holes that are provided for this purpose on the top of the cover.
8. Place the gearbox cover on a wooden pallet.

CAUTION Lift the gearbox cover with care. Lift straight, and keep horizontal to avoid pendulum movement. This will reduce the potential for damage to the bullwheel.

CAUTION Do not place the gearbox cover directly on the ground, as this might damage the jointline and thus lead to future oil leakage. Cover the oil supply bores located in the lower gearbox half so that foreign particles cannot fall into the gear.

If the gearbox will be left open for a certain period of time without any work being done on it, you are advised to cover it with polyethylene foil.

G 4.4 Pinion shaft, seals and bearings

CAUTION Work on the turbomachine must never be carried out by unqualified personnel.

Staff designed to carry out maintenance, inspections and revisions are obliged to read the following instructions and have a close look at the corresponding drawings and supplier documents to familiarize themselves with the equipment and the required techniques prior to working on turbo machines.

We recommend to have all maintenance carried out by AC personnel.

We recommend that you have AC staff exchange spare parts even after the warranty period has expired to maintain the functional warranty applicable to the spare parts.



Adherence to the shaft seals manufacturers' instructions are imperative.

1. Use pulling mandrels for disassembly of the chamber packing. Screw them into the threaded holes provided for this purpose in the chambers. Then, pull out packing.

CAUTION The shaft seals consist of soft material. Do not damage it.

2. After having removed the shaft seals protect the shaft by means of soft material and store the shaft seals at a safe place.
   The gearbox bearings are horizontally split. Bearing replacement does not require removal of the gear and pinion shafts.
   The pinion shaft bearings are secured by bearing caps bolted in the lower section of the gearbox.

3. The joint line of the pinion shaft bearings is offset at an angle to the joint plane of the gearbox, therefore the cylindrical pins must be removed after slightly rotating the bearings. Subsequently, the bearings must be rotated until their joint line is level with the gearbox joint plane.
4. Remove the upper bearing halves, lift pinion shafts somewhat, support them and rotate by 180 degrees and remove the lower bearing halves.
5. Proceed in the same way for dismantling of the bull wheel shaft bearings.
6. Assessing tilting pad bearings, not only the perfect state of the tilting pad running faces is decisive, amongst other things. In particular shocklike bearing load in the event of damage becomes evident by flattened surfaces on the back of the tilting pads.

The back of undamaged tilting pads has an even, straight line-type stripe (mat layer).

Damaged tilting pads, however, show striking conically widened pressure marks. The supporting bodies of the pads have been crushed.

Tilting pads thus damaged must never be re-installed, as their deformations lead to unstable rotor operation.

CAUTION Do not try to break the bearing halves using screwdrivers or chisels. Store the upper bearing half at a safe place. Mark bearings halves, they are not interchangeable. Do not apply marks on the bearing jointline.

CAUTION Take care not to let the pads of tilting pad bearings fall out of the bearing casings. They are easily damaged or might fall into the gearbox. Some pads might be equipped with resistance thermometers.

Take care not to damage the resistance thermometers (if installed).

When dismantling bearings, the cables of resistance thermometers have to be separated from the cable connectors located in the gearbox.

CAUTION Proceed with utmost care whenever you remove seals or bearings to avoid damage to probe measuring surfaces and bearing surfaces.

After bearings or seals have been dismantled, the entire shaft surface must be covered as soon as possible with soft material, e.g. rubber or foam to protect it.

7. The rotors can be removed after the upper bearing halves were disassembled.
8. Lift the pinion shaft slowly and carefully. You will require two people to do this work.

CAUTION Do not damage the shaft when lifting it.

G 4.5 Inspection of core unit parts

During or after disassembly of the parts described in the previous sections, carefully inspect the following parts to determine whether they can be reused or should be replaced.

General inspection Inspect all stationary parts, gearbox, casing assembly (suction casing, diffuser, etc.) before reassembling the parts. Check for cracks or unusual wear.

Impellers Any buildup on the impellers has to be removed either by the use of industrial grade degreaser or by steam cleaning.

CAUTION Be sure not to damage any surfaces of the impeller, especially the mounting surface.

Carefully inspect the impeller for rubs, corrosion, erosion, water damage, or cracks. If any metal (or mass) has been removed from the impeller, it can affect the balance of the rotor assembly and can lead to vibration problems. Rebalance the rotor assembly (see rotor assembly drawings in section 'Drawings').

Shafts Inspect the shafts for wear and scratches in the bearing areas. Investigate any buildup or discoloration in the bearing areas.

CAUTION Never use an abrasive to clean bearing pads or journal surfaces.

Inspect the probe areas of the pinion shafts for scratches or dents. Any marks on these portions of the shaft will give false vibration readings on the vibration monitor.

O-rings Check O-rings. If they are cut, nicked or cracked, or if they do not spring back to round, replace them.

Gears Examine the gears for unusual wear, chips, cracks, or broken teeth.

Bearings Check bearings for excessive or uneven wear, cracks, smearing, scratches, or discoloration.

CAUTION Pay particular attention to the rotor assembly bearings, as failure of one of these high-speed bearings can cause severe damage to the rotating elements in the turbomachine.

Seals Inspect the oil and gas seals for rubs, split line damage, and bent labyrinth teeth. The teeth on the gas seals are on the shaft, not on the seal itself. Minor rubbing on these seals is not unusual. If the labyrinth teeth (on the shaft) are not damaged and the seal has rubbed only slightly (less than 0.125 mm), the seal can be reused.

G 5 Packing of components to return them to AC's works

Whenever inspections carried out in your plant have revealed the necessity to have components evaluated in AC's works, you are requested to proceed as follows to pack and ship the parts:

Turbomachinery rotors Coat bearings, gears and shaft seal with a suitable anti-corrosive agent. The run-out faces of rotors should be additionally protected by means of foam and adhesive tape. The rotors are to be supported at the bearings and shipped in a suitable box. For this purpose, the wood should be provided with grooves, foam material should be placed under the rotor and the rotor should be thoroughly secured to eliminate any shifting in transit. The box must also be provided with the inscription "this side up".

Other turbomachinery components Plug up all threaded connections of turbomachinery components. Apply a film of an anti-corrosive agent to the parts, if possible. Pack the parts in a suited box and secure them against shifting by means of metal tape or wood. The box must also be provided with the inscription "this side up ".

Bearings and other fragile parts Bearings and other fragile parts must also be packed in a way that they arrive at AC safe and protected against corrosion. Provide these parts with a layer of anti-corrosive agent and wrap them in plastic foil.

Suitable anti-corrosive agents

- Shell oil V 9703
- Fuchs-Anticorit TX 10

If these are not available, mix Vaseline with a turbine oil to make a suited grease.

G 6 Cleaning



Danger: detergents and solvents

May lead to skin injuries, acid burns and other severe injuries

- Use only approved detergents and solvents.
- The use of easily inflammable solvents such as benzene, kerosene, naphtha or mineral spirit is prohibited. This applies also to fire-distinguishing liquids such as R12B1. We recommend that you refrain from employing any refrigerants, i.e. fluorinated hydrocarbons.
- Make sure to wear personal protective equipment such as safety goggles, rubber gloves, aprons and, if need be, breathing equipment.
- Make sure to vent closed rooms thoroughly when working with such detergents and solvents.



After use, all detergents and solvents are to be collected in closed containers for proper disposal. Ensure adherence to the warning signs on the containers which give information on which agents may be collected in the individual containers.

Cleaning for inspections

Remove rough impurities from the outside of the machine, before you proceed to open it.

All parts that might be re-used later on must be thoroughly cleaned. This applies also to stand-by parts to be installed.

CAUTION When cleaning the gearbox/bearing carrier jointline make sure that solvent does not drip into the gearbox as this will impair the air separation properties of the lubricating oil.

Recommended detergents

The cleaning methods must be selected in consideration of the type and extent of contamination.

Pre-cleaning by:

- Blowing-off with air
- Wiping, brushing
- Vacuum-cleaning

Highly contaminated parts which are not jeopardized by corrosion caused by contact with water may be cleaned using high-pressure cleaners.

When diluted alkaline solutions are used, e.g. trisodium polyphosphate, these must always be conducted via oil separators or the detergents must be collected and duly disposed of.

These detergents must not be employed to clean plant parts that will come into contact with oil to avoid any neutralization of anti-foam additives contained in the oil by residues of detergents.

De-greasing by:

- Wiping, brushing
- Flushing with approved halogenated hydrocarbons
- Surface treatment e.g. with tetrachloroethylene or methyl chloroform

Cleaning prior to commissioning

The machine and/or its components have been thoroughly cleaned before leaving the AC works after successfully inspection and acceptance by the customer.

To protect the equipment against any contamination during transit to the site, all openings are to be covered by means of covers or plugs and pressurized with nitrogen if necessary.

The equipment should be packed and covered during transit to keep rain etc. from entering.

Cleaning of equipment prior to positioning on the foundation, is only required when visual inspections shows contamination.

Normally, the equipment is erected shortly after it has left the AC works, only checking for damaged packing or covers is necessary.

If the equipment is erected after more than three months, it should to be subject to a thorough inspections by AC staff.

- Remove rough impurities, including rust, from outer surfaces before the components are installed on site.
- Select a suitable place to clean the parts by means of vacuum-cleaning, brushing, wiping or high-pressure cleaners or jet blaster. Make sure to remove all cleaning rags and other foreign matter.

After all rust particles have been removed from the parts, coat the parts with the specified paint.

Cleaning of suction strainer

Dismantle the filter element from the tube or pipe:

Switch of the fluid stream and reduce the pressure in the pipe to atmospheric pressure (please see the Plant Operations Manual). Open the pipe and remove the filter element using appropriate tools.

CAUTION The clean side (inside) must be free from all dirt, under all conditions!

We advise hanging out the filter element on the flange for cleaning purposes, and to blast it with clean air under pressure, from the inside (clean side) towards the outside (dirty side). In this way, particles that have been filtered out will fall off and will not dirty the clean side.

After the cleaning the flange gaskets and the sealing surfaces, the filter mesh and the filter element as a whole should be checked to see if they are in proper condition. Damages if any should be corrected before assembly.

G 7 Re-assembly

For re-assembly of the machine and/or its components or functional groups proceed in reverse order compared to disassembly (See also corresponding drawings). Please observe the following instructions:

CAUTION Compliance with any and all installation clearances shown on drawings "assembly clearances" is mandatory. The valid assembly clearances measured in the workshop will be found in the quality assurance documents.

Current values obtained during assembly must be registered on the associated record sheet.

Compliance with specified tightening torque of screw tensioning devices, in particular that of the impeller tie bolt, is mandatory, i.e. the application of dynamometric keys or hydraulic tensioning devices is imperative.

Where special tightening torque are not expressly specified, the associated screws and bolts must be tightened as shown in the AC Works Standard.



The presence of foreign component affects the safety of the machine.

May lead to injuries

The warranty becomes void.

Whenever turbomachinery parts must be replaced, you are advised to employ exclusively original AC parts or spare parts released by AC.



Before reassembling the parts, clean them thoroughly using industrial degreaser and lint-free cloths.

CAUTION Do NOT use a wire brush on babbitt, brass or aluminum surfaces.

Impeller Prior to installing the impeller, check the Hirth toothing on shaft and impeller for damage.

1. Push the impeller over the impeller bolt pressing it into the toothing in a way that the balancing marks on impeller and pinion shaft coincide. Support impeller in a way that its weight is not carried by the impeller bolt.
2. For light-weight impellers, position the hexagon disk on the impeller hub in a way that here, too, both balancing marks are exactly superpositioned.
3. Tighten shaft nut manually, check clearances, run-out and concentricity considering set values included in drawing "assembly clearances".
4. If deviations are within permissible limits, loosen impeller nut from impeller bolt.

For hydraulically pre-tightened bolts the following is binding for assembly:

- the notes on the rotor drawing or the drawing "assembly clearances"
- the hydraulic pressure required for pre-tightening.

The torque of hydraulically tightened impellers must be effected with highest possible precision. This presupposes perfect operation of the pump pressure gauge.

The prescribed pressure must be built up twice after the connection has been tightened and the pressure relieved for the first time. After the second check pressure is built up, the impeller nut must no longer be adjustable, i.e. the so-called "settling allowance" must have been eliminated.

If the "loosening" torque is smaller than the desired tightening torque, the prescribed pressure must be built up once again.

Build up check pressure again after five minutes. If the "loosening torque" occurs again at a lower pressure, the impeller bolt must be replaced.

In such a case, it is imperative to contact our Service Department.

Rotors Prior to re-installation, check the site of installation for bearings, shaft seals, and toothing to adherence to dimensions and perfect state.

Re-assemble the gear in reverse order to that described above observing manufacturers' instructions. You are requested to use only prescribed sealing agents.

Carbon ring seals

Re-assembly is effected after having checked the packing for potential damage and prescribed clearances. Strict adherence to the prescribed sequence of sealing rings to be installed is imperative.

Arrest pins must be located in the provided grooves to guarantee perfect operation of the packing.

Bearings

Observe the following when installing new tilting pads:

- The axial clearance of the tilting pads in the bearing casing must be 0.20 - 0.30 mm.
- Tilting pads must be freely movable by 0.50 mm in peripheral direction.

The values above apply only, if no restrictions were made in manufacturers' instructions.



The respective manufacturers' instructions listed in the annex are applicable and binding for all work in connection with the gear bearings.

G 7.1 Prescribed tightening torque for screw joints

To ascertain safe plant operation, several screw joints must be tightened in a controlled way, i.e. certain tightening torque must be realized to obtain the required screw pre-tightening torque. For hydraulically tightened torque, the prescribed pressures must be complied with using the tools mentioned in the assembly instructions.

For associated information, refer to:

- Manufacturers' instruction
- Drawings
- Adherence to notes on how to lubricate threads and screw head and nut contact surfaces is imperative.
- AC Works Standard

  Information included in Works Standards must only be used, if there are no manufacturers' instructions or instructions shown on drawings.

  Our Works Standards are based on a 90-% utilization of yield strength. Determining the tightening torque based on this Works Standard screw form (necked-down bolt or not) thread gradient (standard or fine thread), thread size, material strength class (screws are marked 5.6 or 8.8. etc.) and coefficient of friction are decisive factors.

For screw joints without indication by manufacturers or on drawings, the coefficient of friction to be used is 0.125, i.e. slightly oiled, for determination the tightening torque.

Example:

Necked-down bolt M 20 x 1.5; 8.8. To Works Standard, the bolt must be tightened with 329.08, i.e. 330 Nm.

The following screw joints must be tightened with individually fixed torque or hydraulic pressures:

- All gearbox/bearing carrier bolts
- Bearing cap bolts
- Turbine/Booster casing fastening bolts
- Suction casing bolts
- Shaft seal fastening bolts
- Impeller bolts

You are requested to observe the following:

If a loosening torque substantially lower than the tightening torque is sufficient, this might be a hint at the fact that bolts are overstressed. Check bolts, contact surfaces etc.; if required, replace or re-torque.

When replacing bolts, use only bolts of the same material and form.

Prior to tightening any screw joint check the following:

- Can all nuts be easily turned?
- Are all minimum bodies (of tie bolts) undamaged?
- Are all nut contact surfaces clean and without scratching marks?

Nuts of screws tightened by means of hydraulic tightening devices must be easily turneable in tightened state and be brought to contact. Observe information shown on drawings.

When tightening screw joints by means of torque wrench proceed as follows:

- Tighten evenly (cross-wise). Doing so, increase torque gradually until the set value is reached. Allow about 1 minutes for setting after first tightening. Loosen to about 1/10 of the torque or half a turn.
- Tighten until full torque is reached. Loosen to about 1/3 of the torque or 1/4 of a turn.
- Tighten until full torque is reached. Secure, if assembly is ready for operation and if a securing device is provided for.

G 7.2 Information on fits, clearances, alignment values

Generally speaking, fits, clearances, and alignment values must be checked after repairs were made or components were replaced, and re-adjusted to set values. Clearances must never be allowed to fall below the values as stated in the clearance tables. Assessment using mean measuring values, e.g. from four measurements taken at different places, is not permissible. If prescribed clearances cannot be set, you should contact our Service Department.

When effecting assembly work observe that - basically correct - clearances are not altered by tightening pipes and/or pipe supports.

You are requested to observe the instructions on drawings on how to measure clearances or how to align.

G 7.3 Setting of axial distance probes

1. Turn the probe toward the shaft, until the monitor reading is approximately „0“.

Measuring range

Indication

- + 0.8 mm
- (+ 0.0315 in) (higher indication = bigger distance)
- normal
- ‘0’
- counter (lower indication = smaller distance)
- - 0.8 mm
- (- 0.0315 in)

		Example
2.	Push the shaft away from the probe once (use bar). Record indicated value.	0.3 mm normal (0.0118 in)
3.	Push shaft toward the probe once. Record indicated value.	0.1 mm counter (0.0039 in)
4.	Try to find the average of the recorded values. Push shaft into its final position and set the probe in a way that indications in direction „normal“ and „counter“ are just about equal.	± 0.2 mm (± 0.0079 in)
5.	The shaft is now free to move between "0.2 (0.0079) normal" and "0.2 (0.0079) counter". This is the axial clearance.	
6.	Set the alarm 0.15 mm (0.0059 in) above the limit values, i.e. ± 0.35 mm (0.0138 in).	0.35 mm normal (0.0138 in) 0.35 mm counter (0.0138 in)
7.	Set the trips 0.2 mm (0.0079 in) above the limit values, i.e. ± 0.40 mm (0.0157 in).	0.40 mm normal (0.0157 in) 0.40 mm counter (0.0157 in)
8.	Record actually set values. Register set points for alarms and trips resulting from these set values in the set point list.	

CAUTION Whenever limit values are exceeded, i.e. alarms or trips are triggered, the bearing could be damaged. This is to avoid major damage by e.g. the impeller contacting the casing.

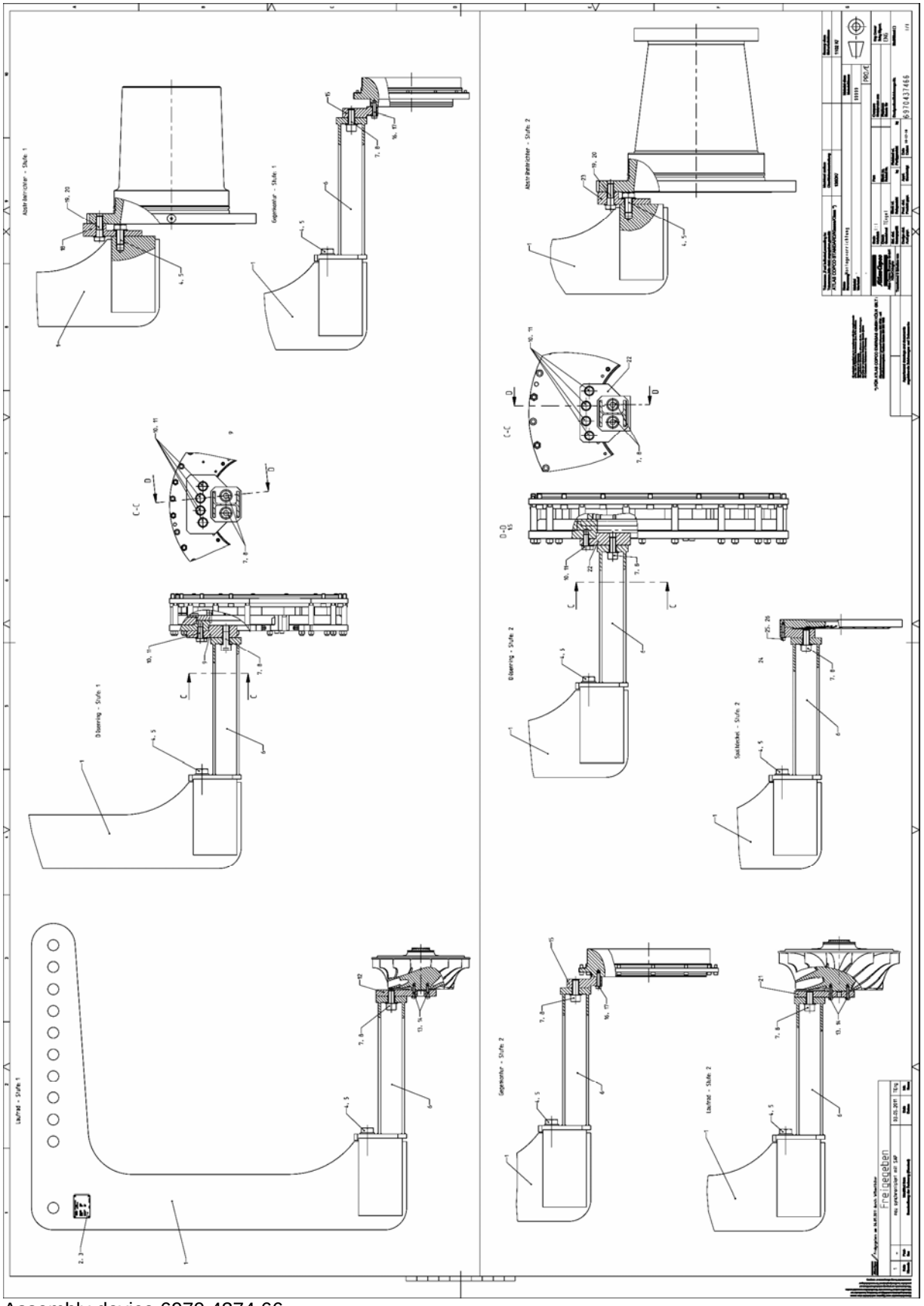
G 8 Tools

Standard tools, e.g. wrenches, dynamometric keys and others are not included in AC's scope of supply. It is assumed that these are available on site.

The same applies to any and all dial gauges and their relevant fastening devices.

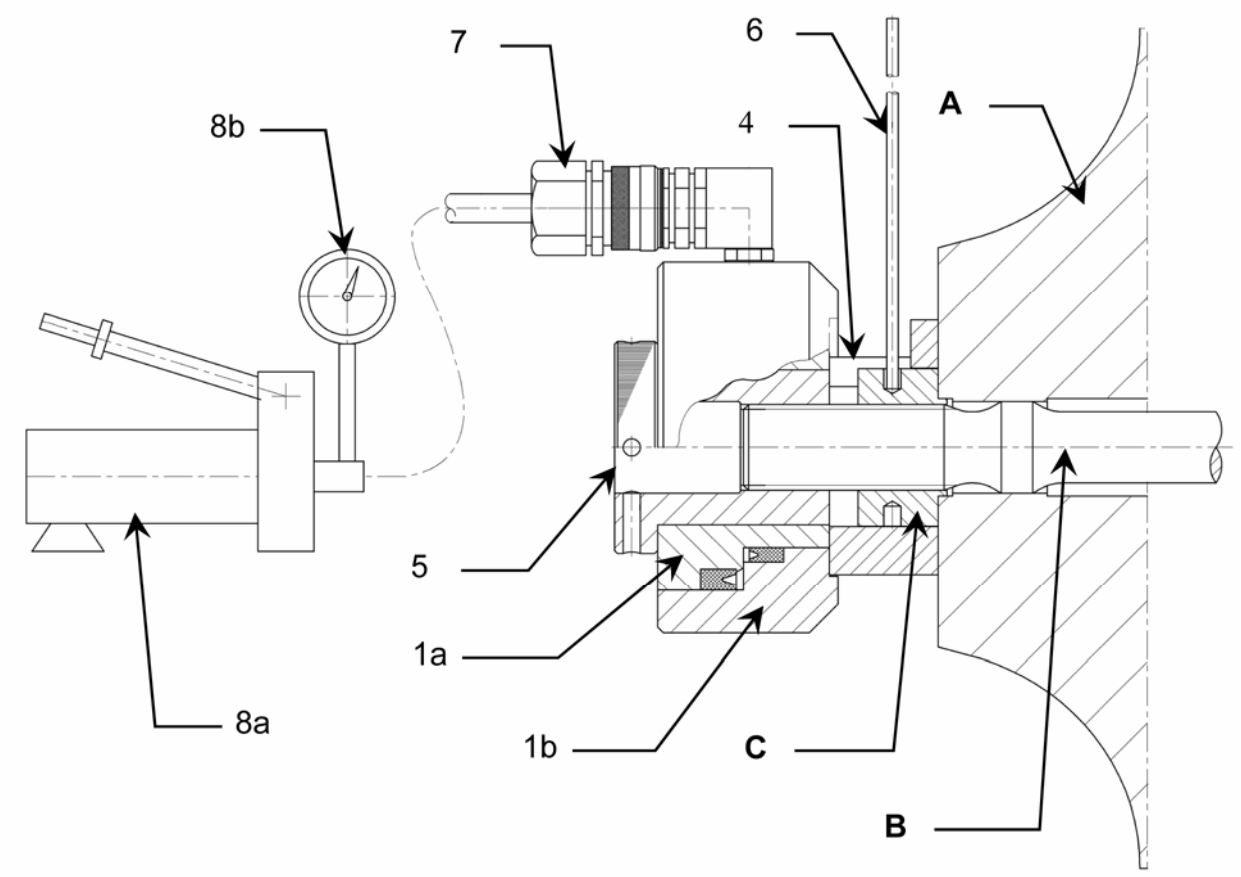
The following list includes special tools required to carry out assembly procedures on the machine; also tool material numbers are added. Please use only tools mentioned here.

	Material number
Pin wrench M85x2 M100x2	6970 4346 57 6970 4346 09
Assembly device	6970 4374 66
Assembly sleeve	6970 4455 09
Hydraulic tensioning device	6970 4344 53
Hydr. Body	6970 1105 51
Distance sleeve	6970 1121 83 6970 1363 06
Tie nut	6970 1121 69 6970 1363 07
Hydr. pump	6970 1009 01
Hydr. pump conversion kit	6970 1009 07
Mounting device coupling hub	6970 3222 17
Hydr. pump	6970 1009 01
Hydr. nut	6970 3222 15
Assembly parts coupling	6970
Round nut	6970
Threaded pin	6915
Threaded plug	6970
Sealing ring	6915



Assembly device 6970 4374 66

G 8.1 Screw pre-stressing device



A	Impeller
B	Impeller tie bolt
C	Impeller nut
1a	Hydraulic piston
1b	Hydraulic cylinder
4	Distance sleeve
5	Tie nut
6	Adjusting rod
7	Hydraulic connection
8a	Hydraulic pump
8b	Pressure gauge

General These operating instructions are designed to inform you about the operation and safe handling of the screw pre-stressing device (referred to hereafter as SSV).

Please read these instructions thoroughly and make sure that they are accessible to all users.

Safety precautions

Safe handling of the SSV and its hydraulic accessories is conditional upon adherence to the general accident prevention regulations and the following instructions:



Tightening torque and pressure refer to rotor drawing and clearence assembly drawing.



Danger to life or physical condition.

May lead to severe injuries.

- When leakages occur during pressurization, de-pressurize immediately and seal the leakage or replace defective parts.
- In case of repair, use exclusively original spare parts. Inexpert replacement of damaged parts by non-original spare parts is prohibited.
- All components are exclusively to be handled as specified in the operating instructions and the assembly drawing. A change in procedure or application of the SSV is prohibited.
- In order to use the SSV, the projecting end of the thread has to be sufficiently long to avoid cracks in thread turns.
- When pressurizing the unit, all staff in question must keep a sufficient safe distance and must be aware not to mantaine a position in line with the direction of the screw axis.
- The SSV must only be operated and handled by expert staff.
- The max. stressing pressure specified on the rotor drawing must not be exceeded in any case. It must be observed at the pressure gauge attached to the hydraulic pump during the entire stressing or loosening procedure. When the specified pressure is reached, stop pressurizing immediately.
- During pressurization, whether tightening or loosening the screw connection, always observe the admissible stroke of the SSV. Any excess in this stroke entails damage to the SSV and danger of accidents or generation of insufficient pre-stressing force.
- When coupling high-pressure hoses, always ensure that the connections are made properly.

- The hydraulic hoses have to be installed in a way that they are not run over by vehicles or walked over by people. Never lay hoses across sharp objects (danger of cutting) and never bend or jam them in (see also chapter: „coupling of high-pressure hoses“.)

CAUTION Following entries on the rotor / assembly clearances drawings has to be considered:

Abbr. of rotor drawing	Abbr.
Initial stress force	**Fvi**
Pump pressure	**pvi**
Special hydraulic device part no.	**Aki**
Total weight of rotor	**m**
Operation speed	**n**
Tightening torque for connection of hub cap	**MKi**
Tightening torque for locking screw of hub cap	**MKsi**
Refer to no. of stage	**i**



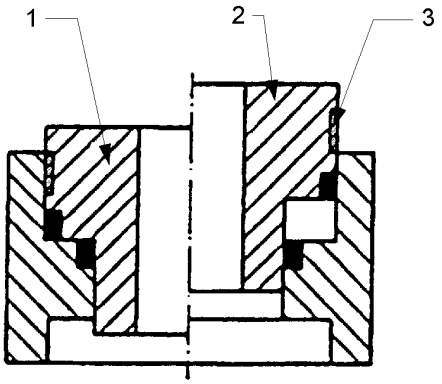
To achieve a high-precision screw connection, it is vital to observe the following instructions:

Prior to applying the device clean all threads and remove any damage to avoid any seizing.

The base plate of the SSV must be level and free of dirt. Furthermore, check that it is at right angles toward the screw axis to avoid the impeller tie bolt being subjected to bending stress during pressurization (stressing).

Stroke indicator The screw stressing device features a stroke indicator that shows when the piston has reached its maximum admissible stroke. The piston of the SSV is provided with a red ring. If the piston is in its zero-position, the ring is hidden by the cylinder of the SSV (see picture).

CAUTION The max. admissible stroke of the SSV is reached, when the signal ring is fully visible. If this is the case, stop pressurizing immediately (refer to items "stressing and loosening procedure").



1 Piston in zero position
2 Piston at max. stroke
3 Signal ring

Coupling of high-pressure hoses

Always couple only when the unit is de-pressurized.

Pull the hose with a manual force of about 100 N to make sure that the connection is correctly tight.

Stressing procedure

Prior to stressing, make sure that the components to be stressed are in the correct position toward each other.

Then, apply the SSV to the bolt as shown on the drawing arranged at the beginning of this chapter. The bore in the piston of the SSV has to align centrally toward the screw axis before the tie nut is screwed on to avoid any inclination of the bolt. Tighten the tie nut until it contacts the front surface of the piston so that the distance sleeve contacts the impeller hub. Also ensure that the piston of the SSV is in its zero position in the process and that the hydraulic connections and the window openings are easily accessible.

After all hydraulic connections have been correctly made, start pressurizing to pre-stress screws by means of the hydraulic pump. When the required stressing pressure is reached, stop pressurizing. The induced force causes the impeller tie bolt to elongate, the components to be stressed to edge, and the impeller nut to lift from the impeller. Use the adjusting rod to screw the nut back to the impeller and relieve the hydraulic pressure from the pump by opening the pressure bleed valve on the generator pump.

Repeat this operation three times to compensate for any settling. Pre-stressing of the screw connection is now accomplished.

After the piston has been returned to its zero position and the hydraulic pressure has dropped to zero (pressure gauge), uncouple the hydraulic hoses.

To prevent impurities, close coupling sleeves and coupling nipples or loosened screw connections at once by applying protective caps.

Unscrew the tie nut and remove the SSV from the impeller tie bolt.

Loosening procedure

Loosening of screw connections is effected as described for pre-stressing.

When the tie nut contacts the front face of the piston and the distance sleeve contacts the flange, turn the tie nut back by half a turn up to one turn of the nut.

Start pressurizing after all hydraulic hoses have been properly coupled.

When pressurizing, a slight de-stressing momentum must be applied to the impeller nut by means of the adjusting rod. Stop pressurizing at the moment the impeller nut can be loosened.

CAUTION

This pressure is slightly lower than the stressing pressure that was applied to pre-stress the connection. Should it turn out to be impossible to loosen the impeller nut when the original pre-stressing pressure is reached, stop pressurizing at once. Contact expert staff to find the associated reason. Always closely observe any and all safety and work instructions.

When the loosening pressure is reached, turn the impeller nut back by the amount that the impeller tie bolt and the components spring back in the course of the loosening operation.



The impeller nut must never be turned back to the extent that it contacts the piston or the cylinder, as this might lead to the SSV being stressed in itself.

Depressurize after the impeller nut has been turned back by opening the pressure bleed valve. Loosening of the screw connection has now been accomplished.

Prior to taking off the SSV return the piston to its zero position (refer to page "Piston return stroke). A pressure of zero has to be indicated at the pressure gauge of the pressure generator. Next, uncouple the hydraulic hoses. To prevent impurities, close coupling sleeves and coupling nipples or loosened screw connections at once by means of protective caps.

Unscrew the tie nut and take the SSV off the impeller tie bolt.

CAUTION Should it be impossible to loosen the tie nut after the pressure has been bled, it has been turned back by too low a measure prior to pressurization. Pressurize again until the original stressing pressure is reached, turn the impeller nut and de-pressurize again (stressing procedure).

Strict adherence to safety and work instructions is mandatory.

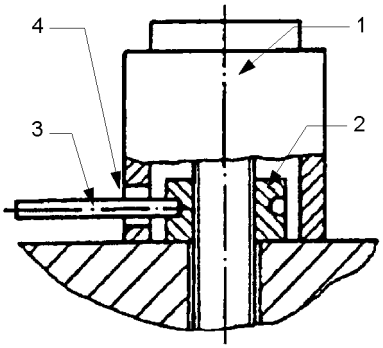
Then, continue to turn the tie nut back.

CAUTION Pay attention to the permissible stroke of the SSV.

Repeat the described loosening procedure.

Adjustment and turnback of the impeller nut

During the loosening procedure, never turn back the impeller nut to the extent that it contacts the piston or the cylinder, as the impeller nut will get stuck after de-pressurization.



1 Screw stressing device
2 Impeller nut
3 Adjusting rod
4 Window opening for adjusting rod

The impeller nut is equipped with several radial bores to receive the adjusting rod (included in scope of supply). The impeller nut is accessible through the window opening in the distance sleeve or in the support cylinder of the SSV.

Piston return stroke

Open the pressure bleed valve arranged on the pressure generator of the SSV to de-pressurize the hydraulic tool.

The manual piston return stroke is effected by further screwing down the tie nut on the impeller tie bolt. In the process, the piston must be brought into contact with the cylinder by means of the tie nut. Then take off the tie nut and remove the hydraulic tool.

Exchanging the gaskets

Should leakages occur at the piston of the SSV, it might be necessary to exchange the gasket.

Drive out the piston by carefully beating with a hammer while using a plastic spacer to protect the SSV from accidental damage. To facilitate the removal of the piston, take off the high-pressure connection and loosen the breather screw, if any.



Danger to life or physical condition.

May lead to severe injuries.

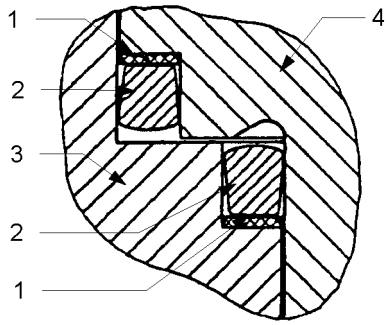
- Sudden input of pressure may lead to an uncontrolled ejection of the piston.

By removing the hydraulic connection it is also possible to conduct compressed air carefully into the piston area. In the process, any breather screw remains closed.

After the piston is taken out, remove the gaskets and the backup rings from the piston and the cylinder.

Carefully clean the single parts using lint-free material and check them for damage. You may use compressed air for cleaning, but never aggressive cleaning liquids. Then apply a slight film of hydraulic oil to the single components and assemble new backup rings and gaskets on piston and cylinder as specified on the drawing.

As illustrated in the picture, first assemble the single backup ring, then place the gasket with its flat side onto the backup ring.



1 Supporting ring
2 Gasket
3 Cylinder
4 Piston

Piston and cylinder can now be re-assembled by putting the components together. Drive in the piston until it fits tightly to the cylinder (piston in its zero position) by slightly tapping on the upper piston part with a hammer (use plastic spacer). It is essential that the piston does not tilt in the process, since this might damage the gaskets and the components.

When installing the piston make sure that air can escape from the piston area.

Maintenance and storage

The SSV does not require regular maintenance, but the following instructions should be observed:

Storage of the SSV

After each application of the SSV repair any damage and clean the SSV to make sure that it is ready for the next application.

To avoid corrosion, we advise to apply a layer of oil to the SSV and in particular its thread. All coupling nipples, coupling sleeves and also loosened screw connections are to be covered by protective caps.

Also check the single components of the SSV and its accessory for completeness; this also includes the manual.

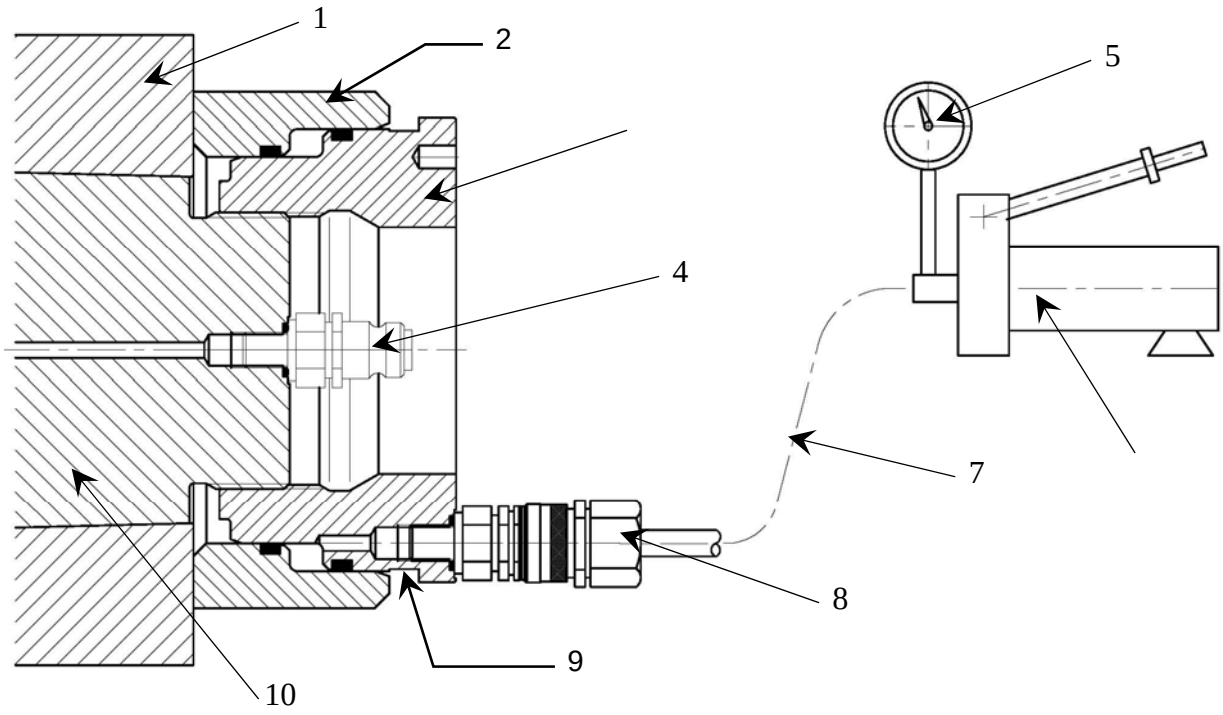
Then, store the SSV in a dry place where it is also protected against any mechanical damage.

Storage room temperatures must range from -20°C to +70°C to rule out any damage to the gaskets.

Vertical storage of the SSV (thread axis vertical) will increase gasket service life.

G 8.2 Assembly of coupling hub with conical seat

*Components of assembly device with hydraulic nut (HN)**



1 Coupling hub
2 Cylinder (HN)
3 Piston (HN)
4 Hydraulic connection shaft journal (arranged centrically or eccentrically)
5 Pressure gauge
6 Manual lever pump
7 Hydraulic hose
8 Hydraulic connection (HN)
9 Stroke indicator (HN)
10 Shaft journal

*The hydraulic nut consists of all components marked (HN).

General information

Adherence to the work and safety instructions applicable to the hydraulic connections and the hydraulic pump included in chapter „screw tightening device“ is imperative.

CAUTION Prior to assembly, check the shaft journal for execution and dimensional accuracy against the coupling, gearbox and shaft drawings. For pressure and temperature values and the pull-on dimensions refer to the coupling drawing.

Two manual lever pumps are required to assemble the coupling hub. In the event of hydraulic oil loss occurring during pressurization, a sufficient amount of hydraulic oil of identical quality (refer to manufacturer's instruction) must be available for any re-fills.

G 8.2.1 Assembly of coupling hub with conical seat (cold assembly)

Work instructions

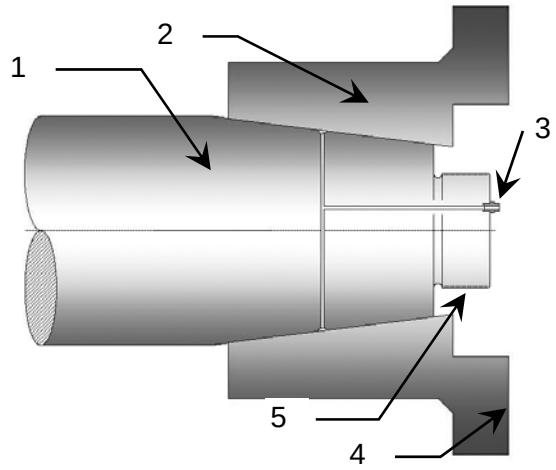
Please read operating instructions of the coupling for assembly, operation, and maintenance.

- Prior to applying the assembly device, clean all threads and eliminate any damage. Thoroughly clean all oil channels/oil bores located on the shaft journal. Provide both shaft journal and thread with a slight film of grease.
- The supporting surface for the HN must be level and free of dirt. Make sure that it is at a right angle toward the center axis of the shaft journal.
- The maximum stroke of the HN must not be exceeded (observe stroke indicator).
- After the hydraulic nut has been loosened, the cylinder must be returned to its zero position.

Any oil emerging while pressurizing must be collected and duly disposed of in keeping with environmental aspects.

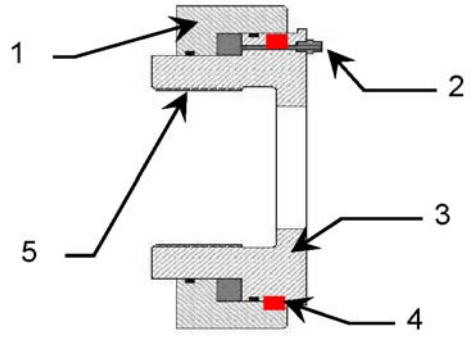
Cold assembly of coupling hub with conical seat

1. Use of lifting equipment is imperative when assembling heavy coupling hubs exceeding a weight of 30 kg. For hydraulic nuts from size 14 (approx. 42 kg), a lifting device will be supplied. It is imperative that the coupling hubs are pushed onto the shaft journal in horizontal/central position, until the stop is reached.
2. Apply a dial gauge on the shaft journal or gearbox casing and secure it. The dial gauge has to be adjusted and set on the measuring position on the coupling hub (refer to figure. 5). Reset the measuring scale of the dial gauge to zero to be able to determine the pull-on path of the coupling hub.



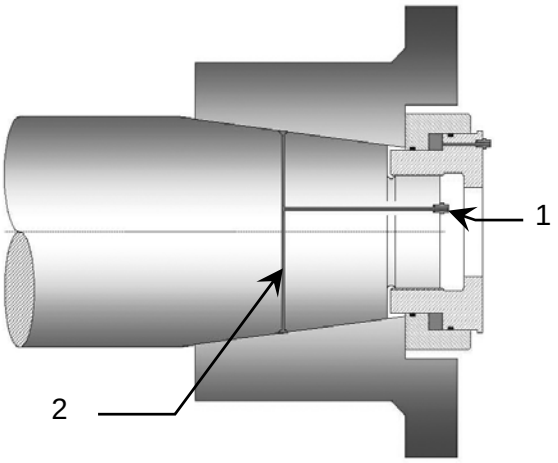
1 Shaft journal
2 Coupling hub
3 Blind plug for hydraulic connection
4 Measuring position for dial gauge
5 External thread of shaft journal

3. Screw the HN onto the shaft journal, until it contacts the coupling hub. In the process, the cylinder of the HN must be in its zero position, i.e. the red stroke indicator arranged on the piston is hidden by the cylinder. Remove blind plug from the shaft journal and insert the hydraulic connection required for the second manual lever pump provided with new gasket and fasten it using screws.



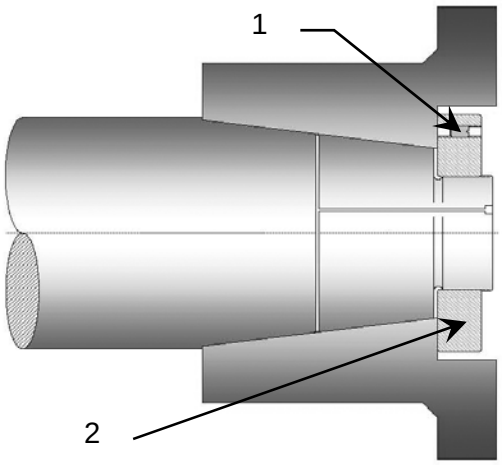
1 Cylinder (HN)
2 Hydraulic connection (HN)
3 Piston (HN)
4 Stroke indicator (HN)
5 Internal thread (HN)

4. Generate all hydraulic connections as specified. Both manual lever pumps must be pumped up evenly and alternately. One manual lever pump is used to pressurize the cylinder of the hydraulic nut, thus pressing the coupling hub onto the shaft journal. The second manual lever pump is used to pressurize the hydraulic connection in the shaft journal, until oil emerges at the shaft journal. The coupling hub is being slightly expanded and lubricated via the oil bores/channels, a fact which somewhat facilitates pressurization.
5. The HN is equipped with a stroke indicator for the max. possible piston stroke. The value (pull-on path) read at the dial gauge has to be continuously checked and compared with the values shown in the coupling drawing.
   If the pull-on path is longer than the stroke of the HN, reduce the pressure built at the HN and shaft journal after a holding time of approx. 20 minutes. Return the piston of the HN to its zero position. Screw the HN, until it reaches the stop, then start pressurizing again.



1 Hydraulic connection
2 Oil bores/channels in shaft journal

6. When the specified pull-on path has been reached, hold the pressure prevailing at the HN for at least 20 minutes (up to 1.5 hours for big coupling hubs) at the same time reducing pressure at the shaft journal.
7. After the holding time has elapsed, unscrew the hydraulic connections from the HN and the shaft journal. Insert the supplied blind plug with sealing ring into the bore of the shaft journal to avoid contamination by dirt particles/foreign bodies.
8. Dismantle the HN and assemble the shaft nut of the coupling hub. Screw the shaft nut, until it reaches the stop, provide the retaining screws with Loctite and tighten them firmly.



1 Retaining screws
2 Shaft nut

When assembling or dismantling the entire coupling, the balancing marks provided on the coupling hubs and the spacer must be observed.

G 8.2.2 Assembly of coupling hub with conical seat (warm assembly)

CAUTION Prior to assembly, check the shaft journal for execution and dimensional accuracy against the coupling, gearbox and shaft drawings. For pressure and temperature values and the pull-on dimensions refer to the coupling drawing.



Danger of burns caused by hot coupling parts.

May lead to severe injuries.

Wear protective clothing to avoid body contact with the hot coupling hub and the hot oil bath.

CAUTION The coupling hub must be evenly heated in hot oil or in an oven at a temperature specified in the coupling drawing and the coupling operating instructions. To avoid premature and uneven cooling of the coupling hub, the process of pulling it onto the shaft must be carried out quickly and at a draft-free place.

Warm assembly of coupling hub with conical seat

1. Push the coupling hub carefully onto the shaft journal in cold condition in horizontal/central position, until it reaches the stop. Mark the position of the coupling hub including the pull-on path on the shaft journal. If required, make a device/stop to ensure that the coupling hub cannot be pulled over the mark when it is hot.
2. Pull coupling hub off the shaft journal and heat it evenly in an oil bath or in an oven as per manufacturer's instructions.
3. Pull the heated coupling hub onto the shaft journal, until it reaches the mark/stop using corresponding protective/auxiliary equipment. Prior to cooling down the coupling hub ensure that it is arranged at a right angle and centrally on the shaft journal.
4. Screw the shaft nut, until it reaches the stop on the shaft journal, provide the retaining screws with Loctite and tighten them.

G 8.3 Disassambly of coupling hub with conical seat

Adherence to the work and safety instructions applicable to the hydraulic connections and the hydraulic pump included in chapter „screw tightening device“ is imperative.

Danger by falling coupling parts

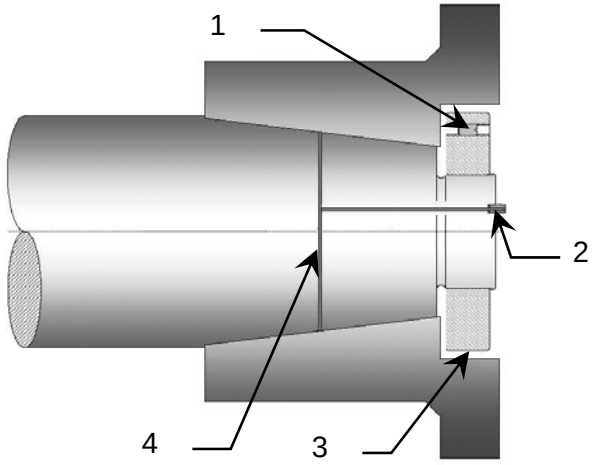
May lead to severe injuries.

When pulling off the coupling hub it is absolutely imperative to remain laterally attached to the coupling hub since the coupling is likely to come off at once without warning.

Secure heavy coupling hubs and shaft nuts against accidental falls.

Disassambly of coupling hub with conical seat

1. Loosen retaining screws and shaft nut by approx. one fourth of the pull-on path. Unscrew blind plug from the shaft journal and screw hydraulic connection with gasket into it.
2. Generate all hydraulic connections toward the manual lever pump as specified. Using the latter, generate as much pressure as required to expand the coupling hub a little bit via the oil bores/channels. In the process, the coupling hub will slip onto the shaft nut.



1 Retaining screws
2 Hydraulic connection
3 Shaft nut
4 Oil bores/channels in shaft journal

3. Use of lifting equipment is imperative when dismantling heavy coupling hubs exceeding a weight of 30 kg. Separate hydraulic connections. Dismantle the shaft nut with care and make sure that the coupling hub does not slip from the shaft journal. After the coupling hub has been dismantled, take the hydraulic connection out of the shaft journal and replace it by the blind plug with gasket.

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H 1 DRAWINGS 3
H 1.1 Drawings of turbomachine 3
H 1.2 Drawings of instrumentation and control 5
H 2 WORKS STANDARDS 7
H 3 RECORDS, FORMS AND CHECK LISTS 9
H 4 SPARE PARTS 11
H 4.1 Notes on how to order spares, example 12
H 4.2 Spare parts delivered with the machine 13
H 4.3 Parts list of mounted plant equipment 13
H 4.4 Parts list 15
H 5 TECHNICAL DOCUMENTATION AND INSTRUCTION MANUALS OF AC'S SUB-SUPPLIERS 17

H 1 Drawings

H 1.1 Drawings of turbomachine

Description	Drawing no.		no. of sheets	Rev
	ACE	Customer		
Foundation plan	6970423423	--	1	6
General arrangement Layout plan	6970423422	--	1	3
P&I diagram	6970423414	--	4	3
Coupling	6970423362	--	1	0
Sectional drawing	6970423411	--	1	0
Assembly clearances	6970423420			
Piping plan water	6970423388	--	3	1
Piping plan oil	6970423390	--	1	0
Piping seal gas	6970429704	--	1	1
	6970441273	--	1	1
	6970441298	--	1	1
	6970441566	--	2	0
	6970441567	--	1	1
	6970441568	--	1	1
	6970441569	--	1	1
Rotor 1	6970423374	--	1	0
Rotor 2	6970423373	--	1	0

Click to the required document and the corresponding file will open in a new window. To go back to the manual, close this window.

H 1.2 Drawings of instrumentation and control

Description	Drawing no.		no. of sheets	Rev.
	ACE	Customer		
Cover sheet	6970423424	--	1	0
Circuit diagram	6970423425	--	170	0
Terminal diagram	6970423427	--	127	0
Cable list	6970424966	--		
Control board	6970423419	--	21	0
Name plates	6970423418	--	8	0
Instrument list machine	6970423417	--	15	0
Instrument list panel	6970424967	--		
Set point list	6970423416	--	10	0
Description of control system				
Screens				
In-/output signals				
Alarm list				
Communication data				
Control diagram				

Click to the required document and the corresponding file will open in a new window. To go back to the manual, close this window.

H 2 Works Standards

During the preparation of this manual the current version of the standard was added. The standards are not subject to change control.

Pressure and tightness tests of pressurized hollow spaces	026.00.1
Surface cleanliness of pressure vessels and piping	033.21.2-1
Preservation of pressure vessels, piping and fittings	033.23.5
Lubricants (recommendation)	Leaflet
Screw tightening torque	903.99.0

Click to the required document and the corresponding file will open in a new window. To go back to the manual, close this window.

H 3 Records, forms and check lists

Document	
Coupling alignment records	
Alignment record	template
Check list for installation	
Check list for commissioning	
Regular maintenance schedule	
Maintenance schedule	
Preventive Maintenance	
Assembly structure	

Click to the required document and the corresponding file will open in a new window. To go back to the manual, close this window.

H 4 Spare parts

Our spare parts lists include all plant assemblies of the core unit and their single spare parts required for each:

- Maintenance,
- Inspection
- Revision or as stock to avoid taking any risk (this is a stock of stand-by parts permitting quick compressor repair in emergencies without causing lengthy standstill periods of the machine caused by long delivery times).

For machine spare parts lists, refer to the following pages.

The first table of the spare parts list contains the parts list number of the assembly group with the corresponding drawing.

The subsequent table contains the original supply order no., description, the no. of the assemblies and the no. of the associated assembly drawing, if any. For each part, its drawing item number is also indicated.



For information about the sub-suppliers assemblies, refer to the corresponding chapters in section H5.

Our spare parts department will prepare a complete spares quotation upon request.

CAUTION Spare parts can either be damaged or rendered useless if they are stored improperly or if the long term conservation packaging becomes damaged.

The spare parts will be delivered in packaging intended for long term preservation of up to 24 months. The integrity of the packaging must be checked periodically. A weekly inspection, complete with signoff verification, is recommended.

If a drying agent is used for preservation, the moisture indicators that are installed must be checked. If the moisture level inside the package is too high, the drying agent must be replaced with a new, professionally prepared package.

After a storage time of max. 24 months, the conservation packaging of the delivered parts must be professionally replaced. Further information on conservation is given in chapter B.

H 4.1 Notes on how to order spares, example

Inquiries or orders should always include the following information:

- Original AC supply order no., AC quotation no.
- Machine type and serial no.
- Drawings and item no., material no. and description of requested spare parts
- Quantity of required parts

Example

Based on your quotation, we order the following parts:

Our order no.	XE 8812
Your quotation no.	140-88-4711
Machine type	GT-040L3K2
Original supply order no.	560 37 123
Serial no.	14-1234

4 set of gaskets, material no. 69XXXXXXXX, item X of drawing no. 69XXXXXXXX.

Should the exceptional case come up that you required components which are not included in our spare part list, we would ask you to describe the component indicating type, function, main dimensions, presumable materials etc. It is always imperative to let us have the associated original AC supply order number.

Be sure that we will help you.



On the following pages the spare parts delivered with the machine are listed.

In general and for a maximum of reliability of the turbo machine we recommend to store at least the following parts:

For start-up

- 1 set of gaskets for turbo machine
- 1 set of gaskets for oil and gas cooler
- 1 set of temperature probes
- 1 set of oil filter cartridges with O-rings
- 1 set of seal gas cartridges (if equipped)
- 1 vibration pick-up

For operation of two years (additional)

- 1 rotor complete
- 1 set of shaft seals (or carbon rings)
- 1 set of oil filter cartridges with O-rings
- 1 set of bearings (radial and axial bearing)

For several years of operation (additional)

- 1 set of bearings (radial and axial bearing)
- 1 set of shaft seals (or carbon rings)
- 1 rotor complete
- 1 set of gear parts (shaft seal, main oil pump, bearings - if equipped)
- 1 set of oil filters cartridges with O-rings
- 1 set of impeller seals (if equipped)
- Service kit for actuators (IGV, DGV, valves, nozzle ring - if equipped)
- 1 set of gaskets for oil and gas cooler

H 4.2 Spare parts delivered with the machine

Refer to parts list.

H 4.3 Parts list of mounted plant equipment

TAG	Denomination	Type	Part-no.
01 FZSC G103	Limit switch	827A.X4-ASH-M10G	part of 01 FY G103
01 PCV G102	Pressure control valve	FRS923-2SK	6915 2629 88
01 PCV G103	Pressure control valve	B74G-4GK-AD1-RMN	part of 01 FV G103
01 PCV G104	Pressure control valve	FRS923-2SK	6915 2629 88
01 PCV G107	Pressure control valve	FRS923-2SK	6915 2629 88
01 PCV G112/G113	Pressure control valve	B74G-4GK-AD1-RMN	part of 01 SV G112.1
01 PCV G174	Pressure control valve	part of generator	part of purge system
01 PCV G207	Pressure control valve	UV4.1 4x6 100F-2	6970 4354 90
01 PCV G212	Pressure control valve	DM613/3"-150 TX32F-2,5 FG	6970 4354 32

TAG	Denomination	Type	Part-no.
01 PSL G205/G206	Pressure switch	EX-DWR 16-513	6970 3998 30
01 SV G102.2	Solenoid valve	24011	part of trip valve 01SV G102.1
01 SV G103/G104	Solenoid valve	L3532CGDoH-2A-52	6970 3820 22
01 SV G112.2	Solenoid valve	24011	part of 01SVG112.1
01 SV G113	Solenoid valve	L3532CGDoH-2A-52	part of 01 FV G113
01 SZSC/O G102	Limit switch	NJ3,5-SN	part of trip valve
01 SZSC/O G112	Limit switch	NJ3,5-SN	part of bypass flap
01 TE G165/G166	Resistant thermometer	TR19B/TW15	6970 3455 59
01 TE G204	Resistant thermometer	TR19B/TW15	6970 4359 98
01 TE G207	Resistant thermometer	TR19B/TW15	6970 4355 59
01 TE G213A/B/C	Resistant thermometer	TR19B/TW15	6970 4355 59
01 TE G216	Resistant thermometer	TR19B/TW15	6970 4355 59
01 TI G165/G166	Temperature indicator (thermometer)	S5413/4 / TW15R	6970 4362 21
01 TI G206/ G209/ G210/ G213	Temperature indicator (thermometer)	S5413/4 / TW15R	6970 4362 21
01 TI G215.1/.2	Temperature indicator (thermometer)	S5413/4 / TW15R	6970 4362 21
01 TI G216	Temperature indicator (thermometer)	S5413/4 / TW15R	6970 4362 21
01 SE G142/G146	Speed sensor	330103	6970 2890 01
01 SE G149A/B/C	Speed sensor	330103	6970 2890 09
01 SE G150A/B	Speed sensor	330103	6970 2890 09
01 SE G151	Speed sensor	330103	6970 2890 11
01 SE G163	Keyphasor probe	330103	part of Generator
01 VXE G141/G142	Vibration probe	330103	6970 2890 03
01 VXE G145/G146	Vibration probe	330103	6970 2890 09
01 VXE G149/G151	Vibration probe	330103	6970 2890 01
01 VXE G163/G164	Vibration probe	330103	part of generator
01 VYE G141	Vibration probe	330103	6970 2890 03

TAG	Denomination	Type	Part-no.
01 VYE G142/G145	Vibration probe	330103	6970 2890 01
01 VYE G146	Vibration probe	330103	6970 2890 03
01 VYE G149	Vibration probe	330103	6970 2890 01
01 VYE G151	Vibration probe	330103	6970 2890 11
01 VYE G163/G164	Vibration probe	330103	part of generator
01 ZE G141A/B	Vibration probe	330103	6970 2890 01
01 ZE G146A/B	Vibration probe	330103	6970 2890 03

H 4.4 Parts list

Click to the required document and the corresponding file will open in a new window. To go back to the manual, close this window.

H 5 Technical documentation and instruction manuals of AC's sub-suppliers

The following list contains the AC's sub-supplier's technical documentation and instruction manuals. Documentation of different components might be found in one register.

Further information regarding the installed components can be found in the instrument list (consumption values), the set point list (operation parameters) and further drawings in chapter 'Drawings'.

The type specification may also contain information regarding the used installation size. Hereby, additional information to the AC's supplier's instruction manual is provided.

Further information can be found in the machine's quality assurance documents (Quality Dossier).



For AC's sub-supplier's documentation and instruction manuals refer to the next folder or the enclosed CD.

Structure of the list of AC's sub-supplier documentation

In the following listing AC's sub-supplier's technical documentation and instruction manuals are ordered by customer TAG numbers (to the extent available) and/or AC TAG numbers. The number in the last column corresponds to the register of the next file, in which the documents are filed away.

On the CD-ROM enclosed the files are ordered by file name. File names start with "H5_" followed by the register number (e.g. H5_01_Motor.pdf).

Sorted by ACE-TAG

Customer TAG	ACE-TAG	Description	Manufacturer	Type	ACE Material No.	Register H5-
--	--	Gear	BHS	WGC3-200	6970 4233 52	1
--	--	Coupling	Renk	MTL 515	6970 4233 62	2
--	--	Dry face seal	Flowserve	Gaspac Type S size 44 size 49	6970 4285 62 6970 4285 63	3
--	--	Carbon ring seals	Espey	WKA 400 HD	6970 4324 21 6970 4325 90	3
--	--	Oil cooler	AEL	--	6970 4233 53	4
--	--	Oil filter	Boll&kirch	BFD	6970 4233 54	5
--	835	Gas filter	Boll&kirch	PDF-P-HD	6970 4345 26	6
--	--	Demister	Franke	FF2-066	6970 4233 56	7
--	P408	Oil pump	Kral	CLL-080.AZABF	6970 4307 63	14
--	P409	Oil pump	Kral	CLL-080.AZABF	6970 4346 88	14
--	--	Generator	LDW	S5E1000M58-4ZP	6970 4233 61	15
--	--	Vibration monitoring system	Bently Nevada	3500	6970 4369 87	22
--	--	PLC	Allan Bradley		Part of control board6970423 380	23
01 E G200	E407	Lube oil heater	Elmess	DHF02B1-3,75-T3	6970 4233 55	8
01 FE G101.A	FE 2130.1	Orifice	SKI	BE 110060	6970 4351 98	9
01 FE G101.B	FE 2130.2	Anubar flow probe	SKI	SDF-F22-24"-S-C-SC-300lbs-FP-DE1-O-H	6970 4351 99	9
01 FIT G126	FT 2563	Flow transmitter	Krohne	H 250 RR M9 ESK EX	6970 4352 25	10
01 FIT G127	FT2565	Flow transmitter	Krohne	H 250 RR M9 ESK EX	6970 4352 25	10

Click to the required document and the corresponding file will open in a new window. To go back to the manual, close this window.

Customer TAG	ACE-TAG	Description	Manufacturer	Type	ACE Material No.	Register H5-
01 FT G101.A	FT2530.1	Diff.-pressure transmitter	Rosemount	2051CD-2-A-0-2-A-1-A-S5-I1-L4-M5-Q8-V5	6970 4360 91	11
01 FT G101.B	FT2530.2	Diff.-pressure transmitter	Rosemount	2051CD-1-A-0-2-A-1-A-S5-I1-L4-M5-Q8-V5	6970 4373 42	11
01 FV G102.1	FV2931	Control flap	OHL	KXF 10 - 2020101009	6970 4233 83	12
01 FV G103	FV 2932	Control valve	Arca	6N7-L1-N	6970 4369 73	13
01 FV G104	FV 2933	Actuator nozzles stage 1	Arca	U3 / 60	6915 2975 80	13
01 FV G107	FV 2934	Pneumatic actuator	Arca	U3 / 60	6915 2975 80	13
01 FV G112	FV2944	Bypass flap	OHL	KXF 10 - 2020101009	6970 4330 72	12
01 FV G113	FV 2945	Control valve	Arca	6N7-L1-N	6970 4233 84	13
01 FY G103	FY 3732	I/p positioner	Arca	827A.X2-A0H-M10G	part of control valve 01FVG103	13
01 FY G104	FY 3733	I/p positioner	Arca	827A.X2-AH-M1	6970 3363 79	13
01 FY G107	FY 3737	I/p positioner	Arca	827A.X2-AH-M1	6970 3363 79	13
01 FY G113	FY 3345	I/p positioner	Arca	827A.X2-AH-M1	part of Control Valve 01FVG113	13
01 FZT G103	FZT3532	Position transmitter	Arca	827A.X4-ASH-M10G	part of 01 FY G103	13
01 FZT G104	FZT3533	Position transmitter	Arca	827A.X2-AH-M1	part of 01FY6104	13
01 FZT G107	FZT3534	Position transmitter	Arca	827A.X2-AH-M1	part of 01FYG107	13
01 FZT G113	FZT3545	Position transmitter	Arca	827A.X4-ASH-M10G	part of 01 FY G113	13

Click to the required document and the corresponding file will open in a new window. To go back to the manual, close this window.

Customer TAG	ACE-TAG	Description	Manufacturer	Type	ACE Material No.	Register H5-
01 LT G204	LT 5597	Level transmitter	Kübler	BMG-2/150/RF-AL-TP43-VK5-M400-V60-MRA-ZTSS200-EX	6970 4048 47	13
01 M G201	M410	Motor	Franke	FF2-066	6970 4233 56	7
01 M G202	M408	Motor	Siemens	IEC200L	part of oil pump 6970 4307 63	14
01 M G203	M409	Motor	Winkelmann	d-GNFZE 2230	part of oil pump 6970 4346 88	14
01 MT G213	MT 2594	Water in oil monitor	Eesiflo	EASZ-1	6970 4353 83	16
01 PDCV G120	PDCV6960	Diff. pressure control valve	Fisher	95LD	6970 4439 59	17
01 PDT G101	PDT6530	Diff.-pressure transmitter	Rosemount	2051CD-3A0-2A1A-S5I1L4	6970 4360 24	11
01 PDT G105	PDT6562	Diff.-pressure transmitter	Rosemount	2051CD-4A0-2A1A-S5I1L4	6970 4360 90	11
01 PDT G108	PDT6564	Diff.-pressure transmitter	Rosemount	2051CD-4A0-2A1A-S5I1L4	6970 4360 90	11
01 PDT G120	PDT6560	Diff.-pressure transmitter	Rosemount	2051CD-3A0-2A1A-S5I1L4	6970 4360 24	11
01 PDT G125	PDT6566	Diff.-pressure transmitter	Rosemount	2051CD-3A0-2A1A-S5I1L4	6970 4360 24	11
01 PDT G211	PDT6592	Diff.-pressure transmitter	Rosemount	2051CD-3A0-2A1A-S5I1L4	6970 4360 24	11
01 PSV G166	PSV6930	Safety pressure valve	Leser	06-315	6970 1935 82	18
01 PSV G204	PSV6996	Safety pressure valve	Leser	4412.4834	6970 4354 93	18
01 PSV G205	PSV6997	Safety pressure valve	Leser	4412.4834	6970 4354 93	18

Click to the required document and the corresponding file will open in a new window. To go back to the manual, close this window.

Customer TAG	ACE-TAG	Description	Manufacturer	Type	ACE Material No.	Register H5-
01 PSV G206	PSV6998	Safety pressure valve	Leser	4412.4844	6970 4355 15	18
01 PSV G210	PSV6979	Safety pressure valve	Leser	06-315	6970 1935 82	18
01 PT G121	PT6561	Pressure transmitter	Rosemount	2051TG-2-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4361 59	11
01 PT G122.A	PT6563.1	Pressure transmitter	Rosemount	2051TG-1-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4361 80	11
01 PT G122.B	PT6563.2	Pressure transmitter	Rosemount	2051TG-1-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4361 80	11
01 PT G122.C	PT6563.3	Pressure transmitter	Rosemount	2051TG-1-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4361 80	11
01 PT G123.A	PT6565.1	Pressure transmitter	Rosemount	2051TG-1-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4361 80	11
01 PT G123.B	PT6565.2	Pressure transmitter	Rosemount	2051TG-1-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4361 80	11
01 PT G123.C	PT6565.3	Pressure transmitter	Rosemount	2051TG-1-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4237 48	11
01 PT G213A	PT6594	Pressure transmitter	Rosemount	2051TG-2-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4362 15	11
01 PT G213B	PT6595	Pressure transmitter	Rosemount	2051TG-2-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4362 15	11
01 PT G213C	PT6596	Pressure transmitter	Rosemount	2051TG-2-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4362 15	11
01 PT G214	PT6597	Pressure transmitter	Rosemount	2051TG-2-A-2B-2-1-A-S5-B4-I1-M5-V5	6970 4362 15	11
01 ST G142	ST3501	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ST G146	ST3503	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ST G149A	ST7502	Proximitor	Bently Nevada	330180-91-05	6970 2275 74	19

Click to the required document and the corresponding file will open in a new window. To go back to the manual, close this window.

Customer TAG	ACE-TAG	Description	Manufacturer	Type	ACE Material No.	Register H5-
01 ST G149B	ST7503	Proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ST G149C	ST7504	Proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ST G150A	ST7505	Proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ST G150B	ST7506	Proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ST G151	ST3514	Proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ST G154	ST7509	Accelerometer	Bently Nevada	330400-02-05	6970 3237 51	19
01 SY G102.1	SY 2931	Pneumatic actuator	Remote Control	RC280 SRQ060	part of trip valve	12
01 TCV G208	TCV 8991	Temperature control valve	MVA	M80TD5G110DB	6970 4377 66	20
01 TIT G1160	TT8524	Tremperatur transmitter fieldhousing with indication	Rosemount	3144P	6970 4362 16	21
01 TIT G1161	TT8525	Tremperatur transmitter fieldhousing with indication	Rosemount	3144P	6970 4362 16	21
01 TIT G1162	TT8526	Tremperatur transmitter fieldhousing with indication	Rosemount	3144P	6970 4362 16	21
01 VXT G141	VT9502	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VXT G142	VT9503	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VXT G145	VT9504	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VXT G146	VT9506	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VXT G149	VT9515	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VXT G151	VT9513	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VXT G163	VT 9520	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VXT G164	VT9522	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VYT G141	VT9501	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19

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Customer TAG	ACE-TAG	Description	Manufacturer	Type	ACE Material No.	Register H5-
01 VYT G142	VT9504	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VYT G145	VT9503	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VYT G146	VT 9506	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VYT G148	VT9516	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VYT G151	VT9514	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 VYT G163	VYT9521	Vibration proximitor	Bently Nevada	330180-91-05	BY GENERATOR SUPPLIER	19
01 VYT G164	VT 9523	Vibration proximitor	Bently Nevada	330180-91-05	BY GENERATOR SUPPLIER	19
01 ZT G141A	ZT9505	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ZT G141B	ZT9506	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ZT G146A	ZT9507	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19
01 ZT G146B	ZT9508	Vibration proximitor	Bently Nevada	330180-91-05	6970 2275 74	19

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