TURBOCHARGER

TYPE HS 400

MAINTENANCE MANUAL

MANUFACTURED BY HISPANO-SUIZA
DIVISION OF SNECMA

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DISASSEMBLY

10. DISASSEMBLY

10.1. Important recommendations about maintenance work on turbocharger

- Scrupulous cleanliness must be observed while doing maintenance work
- Handle the parts with great care; avoid any shock especially to the delicate parts ; turbine wheel and impeller (blades and vanes), nozzle guide vanes, journal and thrust bearings.
- In contact with metal parts, use only bronze hammers or plastic mallets specially provided for that purpose.
- Carefully examine each part after disassembly.

10.2. Tools

Use the special tools listed in section 80, para. 80.1.1.

10.3. Disassembly procedure - Plate No 1

a) Removal of turbine nozzle assembly (60)

b) Removal of turbine (51)

c) Removal of air intake duct (126)

d) Removal of compressor casing (101)

e) Removal of impeller (90)

f) Removal of rear bearing (30)

g) Removal of shaft assembly (8)

h) Dismantling the assemblies.

10.3.1. Removal of turbine nozzle assembly

- unlock and remove the bolts (82)
- reject the tabwashers (81)
- remove the nozzle assembly (60)
- retain the locating pins (80) note their location
- reject the gasket (79)

10.3.2. Removal of turbine

- hold the shaft with spanner 928/78
- unlock and unscrew the nut (59) with spanner 928/78
- reject the tabwasher (58)
- withdraw the turbine (51) with the appropriate extractor gripping on the turbine disc collar. The extractor 925/78 is to be used for turbines with inserted blades and extractor 96900/78 for turbines with integral blades.
- remove the adjusting washers (50)

10.3.3. Removal of air intake duct

- remove the bolts (127) and reject the tabwashers (128)
- retain the plain washers (129)

10.3.4. Removal of compressor casing

- unscrew the nuts (112)
- reject the lockwashers (111)
- remove the compressor casing (101). If necessary use jacking screws in the tapped holes (6 mm dia., 0.100 pitch) provided in the gas outlet casing (3)
- reject the O'ring seal (110) of diffuser (70).

NOTE : No attempt should be made to remove a diffuser secured to the cover (84) by tie-bolts and nuts. See para. 10.3.8.c

10.3.5. Removal of impeller

- hold the shaft (9) with the spanner 928/78.
- unlock and remove the nut (100) (spanner 927/78)
- reject the tabwasher (99)
- withdraw the impeller (90)
- remove and retain the adjusting washers (98).

10.3.6. Removal of rear bearing

- unlock and remove the bolts (39)
- reject the tabwashers (37-38) or double tabwashers as applicable
- remove the turbine labyrinth seal (36). Il necessary use jacking screws in the tapped holes (8 mm dia., 1,25 pitch) provided.
- reject the gasket (35)
- remove the oil deflector ring (34) and the adjusting washers (50) which are still on the shaft.
- remove the bearing (31). If necessary use jacking screws in the tapped holes (8 mm dia., 1.25 pitch) provided
- reject the O'ring seal (28) and gasket (29)

10.3.7. Removal of shaft (8) front bearing (15) and thrust bearing assembly

- unlock and remove the bolts (27), reject the tabwashers (26)
- remove the bearing oil seal (25). If necessary use jacking screws in the tapped holes (8 mm dia., 1.25 pitch) provided.
- reject the gasket (24)
- withdraw the shaft-front-bearing-thrust bearing assembly. If necessary use jacking screws in the tapped holes (8 mm dia., 1.25 pitch) provided in the front bearing.
- reject the gasket (23).

10.3.8. Dismantling the assemblies

a) Removal of thrust bearing and front bearing from the shaft.

- clamp the shaft and bearings assembly vertically in a vice fitted with leaden jaws

- unlock and remove the bolts (21)
- reject the tabwashers (20)
- remove the spring pin retaining washer (19)
- remove the first thrust washer clamp plate (13)
- remove the spacer (12)
- pull the shaft (9) out of the bearing
- remove the two thrust washers (10) (11)
- remove the second thrust washer clamp plate (13)
- remove the dowel pins (14), detail A

b) Removal of diffuser cover (83) or (84)

- remove the screws (89)

c) Removal of diffuser

- Diffuser (85) figure detail B secured with screws
  - remove the screws (109)
  - remove and retain the shims (108)
- Diffuser (85) secured with tie-bolts P/N 6489 and nuts P/N 6509
  - grind off the peened portion at the end of the tie-bolts (86)
  - unscrew the nuts (88)
  - remove the washers (87)
  - remove and reject the tie-bolts and nuts
- Diffuser (85) secured with tie-bolts P/N 53460 and nuts P/N 400481.
  - unscrew the nuts (88)
  - remove the washers (87), nuts (88) and tie bolts (86)

d) Removal of nozzle guide vanes (65)

NOTE : Operation to be carried out after inspection of the assembly (see Section 30, para.30.1.1)

- unlock and remove the bolts (77), reject the tabwashers (76)
- mark each vane and locating slots (in inner and outer rings) using a grease pencil, wax crayon or a scriber
- remove the rings (73) (74)
- remove the vanes from the rings.

NOTE : The last three operations apply only to nozzles whose guide vanes are not argon arc welded to the inner ring.

e) Disassembly of spacer (65) and gas intake casing (62) figure detail C

- unlock and unscrew the nuts (71), reject the tabwashers (70)
- remove the bolts (69)
- reject the gas intake casing gasket (64).

f) Removal of heat shield (113)

- unscrew the bolts (115)
- remove the plain washers (114)

g) Exhaust casing

The taper plugs will be removed only in case of leakage - see section 30 para. 30.1.4.

20

CLEANING

20. CLEANING

20.1. CLEANING OF STEEL AND CAST-IRON PARTS

See section 70

20.1.1. Cleaning agent; ARDROX grade 185E2

- turbine (disc and blades)
- nozzle (rings - vanes)
- shaft
- compressor inducer (rotating guide vanes)
- gas intake casing - spacer
- exhaust casing
- turbine labyrinth seal.

a) Procedure

- use a stainless steel tank
- proportion ; 300 g of cleaning agent per litre of water
- temperature of cleaning solution : 80 to 100° C
- immerse the parts for 45 minutes
- rinse in cold running water
- dry with moisture-free compressed air

b) Protection after cleaning with ARDROX

- use ARDROX 39/1 corrosion preventive
- proportions : 1 part (by volume) of corrosion preventive for 6 parts (by volume) of White Spirit.
- immerse the parts for more than 5 minutes

CAUTION : Do not use the above cleaning agent and corrosion preventive for aluminium parts. See section 20 para. 20.2.

20.1.2. Cleaning with dilute nitric acid

- turbine disc with integral blades
- turbine blades
- nozzle guide vanes
- nozzle rings

Procedure

- bath composed of 25 % nitric acid and 75 % water by volume :
  - immersion time :
    - turbine with integral blades, turbine blades and nozzle guide vanes : 1 ½ hour
    - nozzle rings : 1 hour

NOTE : For welded nozzle assemblies the immersion time shall be limited to 1 hour.

- turbine disc : for a short time (exceptionally 10 minutes)

- rinse with air-water-gun
  - air pressure : 4 kg/sq.cm approx.
  - water pressure : 6 kg/sq.cm approx.

NOTE : Heavy fouling of turbines and nozzle guide vanes may require mechanical cleaning of parts by subjecting them to a blast of ground apricot stones (apricot peening).

2.1.3. S.P.C.A. cleaning agent

- exhaust casing
- painted parts with loose carbon deposits from exhaust gas.

a) Method No 1

"NETAL D 91"

Procedure

- depending on the type and extent of fouling
- mix 1 part of cleaning agent with 1 to 3 parts of water. Stir the mixture to facilitate dissolving of cleaning agent
- immerse the parts for more than 30 minutes
- if necessary brush the parts with a soft brush to remove any remaining carbon deposit
- rinse with a high pressure cold water jet.

b) Method No 2

"NETAL AC"

If cleaning using the first method gives insufficient results, the parts should then be cleaned by immersion in an air-agitated bath (e.g. supply of low compressed air flow at the bottom of the tank) made up as follows :

- one part of "NETAL AC"
- one part of heavy solvent such as Shellsol A, or any similar solvent with a distillation range of 160 to 190° C.

Procedure

- immerse the parts in the solution for more than 30 minutes.
- if necessary brush the parts with a soft brush
- rinse the parts liberally with a high pressure cold water jet.

c) ORTHONETOIL P cleaning agent

- gas intake casing
- turbine nozzle
- turbine disc (blades)
  (adhering carbon deposits formed at high temperatures)
- turbine labyrinth seals.

Procedure

IMPORTANT NOTE : The ORTHONETOIL P cleaning fluid shall be covered with a layer of water 15 to 20 cm high, in order to prevent evaporation of active solvents.

- immerse the parts in the bath at a temperature of 70° C for more than 2 hours
- rinse the parts with a high pressure cold water jet
- brush the parts if necessary.

NOTE : Avoid prolonged immersion of rubber, synthetic elastomer and plastic material components which would be disintegrated.

WARNING : All the foregoing cleaning operations require that usual safety precautions be observed, i.e. :

- PROPER VENTILATION OF WORKSHOPS
- OPERATORS WEARING GLOVES AND GOGGLES.

20.2. CLEANING OF ALUMINIUM PARTS

- compressor casing
- compressor impeller
- diffuser cover with or without diffuser

Either of two cleaning methods may be used :

- by spraying the cleaning fluid on the parts
- by immersing the parts in a bath

20.2.1. Spray cleaning with ARDROX grade 607 or 6061 or 6025

Procedure

- use a stainless steel tank
- cleaning mixture : 10 to 25 % Ardrox mixed with White Spirit at room temperature,
- spray the mixture on the part with a cleaning spray gun
- rinse the part with a water jet.

20.2.2. Immersion cleaning with ARDROX grade 6003 or 60 S

Procedure

- use a stainless steel tank
- mixture : 2 to 5 % in water
- heat the mixture to 70 - 100° C
- immerse the parts of 5 minutes
- rinse in cold running water.

NOTE : The use of ARDROX and S.P.C.A. cleaning fluids is not mandatory. The operator may at his discretion use similar cleaning products having the same properties.

20.3. GENERAL CLEANING

- use White Spirit
- brush the parts with a stiff-haired brush
- dry with moisture-free compressed air.

20.4. SPECIAL CLEANING PROCEDURE FOR THE OIL PASSAGES TO THE BEARINGS

- unscrew the plug (7)
- smear a 12 mm. dia. drill with generalpurpose grease and insert it in the oil passage. Move the drill back and forth while rotating it to remove any particle of foreign matter.
- proceeding in the same manner cle n the small diameter oil hole at the end of the oil passage with a 3 mm. dia. drill inserted from the rear bearing housing in the casing.
- carefully clean the oil passages by injecting White Spirit.
- blow the passages with moisture-free compressed air.
- inspect the oil passage for cleanliness
- cover the threads of plug (7) with three turns of teflon tape taking care not to cover the first two threads to prevent any teflon particles possibly torn off while tightening the plug from blocking up the oil passage.
- refit and tighten the plug.

30

INSPECTION AND CHECKS

30. INSPECTION AND CHECKS

30.1. EXHAUST GAS INLET SECTION

30.1.1. Gas intake and nozzle assembly

It includes the following parts :

- gas intake casing
- casing spacer (turbochargers series 28000)
- outer ring
- inner ring
- nozzle guide vanes
- bolts, nuts and tabwashers

After cleaning manually check the assembly as detailed below and if necessary carry out a dimensional check of the nozzle assembly.

NOTE : The assembly will be disassembled only if one of its components fails to pass the inspection.

a) Manual check

- check the vanes by hand for radial movement. If this seems abnormal, carry out a dimensional check.
- check the vanes do not move laterally in their locating slots (inner and outer rings).

b) Dimensional check (see section 60)

- check the clearance K
- check the vane trailing edges for angular movement A (see plate 2). Movement shall be measured at mid-length of the trailing edge.
- mark the vanes (and slots) whose movement A is :
  - within limits for reassembly : $A \leqslant 0.5$
  - within limits permitting the salvage of parts : $1.5 > A > 0.5$
  - at rejection limit
- disassemble the nozzle assembly (see para. 10.3.8.d)

30.1.2. Gas intake casing and spacer

a) Visual inspection

Check the condition of :

- gas passages
- gas passage walls on nozzle side. Cracks, if any, are tolerated without any limitation with regard to their length, provided that they do not extend to the outside surface.
- nozzle ring locating surfaces - possible marks caused by vanes
- attachment flange, see plate 2.
- slots "F1" provided to accommodate the locating pins
- attaching bolt holes
- only one crack per hole extending to the outer edge of the flange is acceptable (detail B, plate 2)
- tapped holes for bolts securing the following components : turbine nozzle, heat shield, exhaust manifolds.

NOTE : If the exhaust manifolds are secured by means of studs check the studs are not loose in their tapped holes.

b) Dye penetrant inspection of gas intake casing or spacer
- Inspect the external part at the location of the partitions
- Use the penetrants provided for that purpose (section 70)

c) Dimensional check (section 60)
- This check to be carried out only if large variations in nozzle guide vane radial movement (clearance K) have been noted (see para.30.1.1.b)
- Measure the locating "Z" diameter of nozzle outer ring in casing or spacer at 8 points
  - use slide calipers

30.1.3. Turbine nozzle

The turbine nozzle is composed of :
- the outer ring
- the inner ring
- the nozzle guide vanes

a) Visual inspection

1. Nozzle rings
   - inspect the ring locating surface that fits in the casing or spacer (Turbochargers series 28000)
   - check the surface condition of that portion of the ring acting as turbine shroud
   - check the condition of the securing bolt holes
   - check the condition of the tapped holes for jacking screws
   - check the condition of the vane locating slots : there should be no peening marks
   - inspect the inner ring by the dye penetrant process. Use the penetrants provided for that purpose (section 70)

2. Nozzle guide vanes - Plate 3 (viewed from trailing edge side)
   - inspect the vanes by the dye penetrant process
   - use the penetrants provided for that purpose (section 80)
   - inspect the leading edge and the aerofoil section for impact marks; a few slight impact marks are tolerated if they have not caused distorsion.

   - Cracks
     - no crack is allowed

     NOTE : This instruction concerning the non-acceptance of cracks will possibly be revised and the acceptance of cracks permitted to some extent in the light of observations made at overhaul.

   - Inspect the trailing edge for :
     - distorsion, impact marks, bent edge, cracks.

   Distorsion - detail A
   - bowing to a maximum of 0.70 mm is permissible.

   Impact marks - detail B
   - two impact marks with a maximum depth of 0.70 mm. are permissible provided that :
     - they do not have sharp angles likely to cause incipient cracking

- the minimum distance between two impact marks is 15 mm. (detail C)

- bent edge - detail D
  - a bent edge is permissible providing the bent portion does not exceed 1 mm. in width and 4 mm in length per vane (along vane height)

IMPORTANT : A vane showing an impact mark and a bent edge shall be mandatorily replaced.

- Inspect the vane platforms for :
  - peening marks due to fluttering

- Mixing of vanes at reassembly.

The maximum permissible number of "accepted" vanes with impact mark or bent edge refitted at assembly is limited to 50 % of the total number of vanes in the nozzle assembly; these vanes shall be mixed with new vanes.

The number of new vanes to be fitted is unlimited.

b) Dimensional check (see section 60)

1. Outer ring

- The dimensional check carried out as in para. 30.1.1.b has enabled to mark the vane locating slots according to limits of permissible vane angular movement.
  Outer rings with one or more slots giving a vane angular movement greater than 1.5 mm when fitted with a new vane should be rejected.
  Outer rings with one or more slots giving a vane angular movement between 0.5 and 1.5 mm when fitted with a new vane can be repaired by an electric forging operation intended to reduce the clearance in both outer and inner rings and carried out with the complete nozzle assembly mounted in a special fixture. This operation is accomplished in HISPANO-SUIZA workshops in accordance with a special repair scheme.
  For slots giving a vane angular movement A $\leq$ 0.5 mm as revealed by the dimensional check per para. 30.1.1.b an attempt to obtain the minimum clearance should be made by interchanging vanes or replacing the particular vanes by new ones.
  If after visual inspection and dimensional check the ring is found satisfactory fit it into the gas intake casing or spacer (both found in good condition too) belonging to the turbocharger being inspected.

The ring must fit freely without any tight spots. If there are tight spots :
- check that no carbon deposits remain at tight spot locations. If any remove them.
- measure the diameter "Z" that locates the ring in the casing or spacer taking measurements at 8 points.

2. Inner ring

The instructions given in the above paragraph for the outer ring are also applicable to the inner ring.
Check the inside diameter C1.

3. Nozzle guide vanes

- Check the dimensions "A2" and "B2" of the locating platforms of the vanes marked during the check specified in para 30.1.1.b.

30.1.4. Exhaust casing

a) Visual inspection.

Inspect :

- the diameter and face mating with the gas intake casing or spacer for possible damage
- the compressor casing mating face and locating diameter for possible damage
- the bearing housings
- tapped holes for possible damage
- oil feed passages and holes to the bearings and pressurizing air passages which must be perfectly clean (presence of foreign matter). See para.20.4.
- the gas intake casing or spacer locating dowels for condition no wear is permissible
- using the penetrants provided for that purpose (section 70) inspect by dye penetrant process areas liable to cracking around plugs and reinforcing bosses on intake casing side.
- Check the cooling water and oil systems for leaks
  - blank off the water or oil return port with a plug
  - connect the water or oil inlet port to a source of moisture-free compressed air (5 bars min. pressure (5 kg/sq.cm approx.) by means of a pipe fitted with a shut-off valve and pressure gauge.
  - immerse the casing in a hot bath of paraffin (kerosene)
  - pressurize the system at 5 bars
  - check that there are no leaks.

b) Dimensional check

- No check is to be carried out.

30.2. AIR INTAKE SYSTEM

30.2.1. Compressor casing

a) Visual inspection

Inspect :

- the air intake annulus for surface condition, possible impact marks, rubbing marks
- studs for damage and possible loosening
- helicoil wire thread inserts for possible damage or loosening-check they are 0.2 to 1 mm underflush from the casing face

- the following surfaces for condition
  - face mating with diffuser (turbocharger with diffuser secured to casing with screws)
  - O'ring seal seating surface (turbocharger with diffuseur secured to casing with tie-bolts)
  - face mating with the exhaust casing.

b) Dimensional check

No check is to be carried out.

30.2.2. Diffuser

a) Visual inspection

- on both types of diffuser (secured by tie-bolts or screws)
- inspect the diffuser by the dye penetrant process for possible cracks in the vanes
- use the penetrants provided for that purpose (section 70)
- examine the vanes for condition of :
  - leading edges : possible impact marks
  - root fillets (no cracks)
- on diffusers secured with tie-bolts :
  - inspect :
    - the tie-bolt hole counterbores : possible wear marks, maximum depth 0.2 mm., check that the bolt head cannot rotate.
    - the tie-bolt holes for ovality
    - the O'ring seal groove for condition
- on diffusers secured with screws :
  - check the condition of :
    - the screw holes
    - the vane faces mating with the cover.

b) Dimensional check

- No check is to be carried out.

30.2.3. <u>Diffuser cover</u>

a) Visual inspection

Inspect :

- the labyrinth seal lips for possible signs of rubbing of the impeller
- the inner surface on impeller side and at location of diffuser vanes for condition : possible peening marks
- the diameter surfaces locating the cover
  - in the compressor casing
  - in the gas exhaust casing.

b) Dimensional check

In case where light rubbing marks are noticed on the labyrinth seal lips, measure :

- the diameters R1-S1-T1-U1 of seal lips
- the diameters locating the cover in the exhaust casing
- use slide callipers for this measurement.

30.3. ROTATING ASSEMBLY

30.3.1. Impeller assembly

It consists of :

- the inducer (rotating guide vanes) and bush assembly
- the impeller and bush assembly and dowels

a) Visual inspection

Inspect :

- the leading edges of the impeller and inducer vanes for possible impact marks, distortion - see plate 4

On the leading edge of each vane :
- 1 impact mark, 1 mm deep or
- 2 impact marks, 0.7 mm deep

are acceptable.

On the vane surfaces
- a few light impact marks are acceptable providing they do not cause distortion.

- the impeller labyrinth seal lips (possible signs of rubbing)
- the bore of the bushes fitted in the impeller and inducer; check the bushes are a tight-fit (no loosening)
- the inducer internal splines for wear, distortion and twisting. Use the splined plug gauge provided.
- the locating dowels for condition and security (tight fit)
- the dowel holes in the impeller for possible ovality.
- Inspect the assembly for cracks by the dye penetrant process
- Use the penetrants provided for that purpose (section 70).

NOTE : This inspection shall also be carried out after dressing any impact marks.

b) Dimensional check (see section 60)

- In case of peening or wear marks in the impeller and inducer bushes :

  - check their inside diameters at 4 points.
    Refer to the table of Fits and Clearances, section 70
    - impeller bush diameter "B"
    - inducer bush diameter "W"

- In case of signs of rubbing of the labyrinth seal lips :
  - check the diameters R2-S2-T2-U2 of the labyrinth seal lips .

NOTE : The face at the tip of the lips must be square with the impeller bore.

c) Balancing check

MOST IMPORTANT : After any rectification work on the compressor impeller or inducer and also after replacement of either part, the assembly shall be checked for balance.

NOTE : The impeller and inducer form a matched assembly. Either component of this assembly must not be interchanged with the components of an other impeller assembly.

d) Balancing check procedure (for information)

(1) Determining the amounts of unbalance

- place the impeller-inducer assembly in the balancing machine
- set the machine to read zero by applying modelling clay or putty to :
  the inducer : at a radius selected in the plane of its c.g
  the impeller : on the balancing land.

(2) Calculating the amounts of unbalance

Inducer : weight of putty (g) x selected radius (cm) = a (g.cm)
Impeller : weight of putty (g) x land radius (cm) = b (g.cm)

NOTE : The values a and b shall be at points angularly offset by 180°.

(3) Dynamic torque

$$a \times \frac{\text{distance of unbalance planes}}{2} + b \times \frac{\text{distance of unbalance planes}}{2}^2 \leqslant 20 \text{ cm.g.cm.}$$

(4) Static unbalance

$$a - b \leqslant 1 \text{ g.cm.}$$

Example :

Inducer : selected radius : 7 cm

Impeller : balancing land radius : 8 cm

Distance of unbalance planes : 6 cm

Weight of putty in each plane : 0.4 g

Calculation of unbalance amounts

a = 0.4 x 7 = 2.8 g.cm
b = 0.4 x 8 = 3.2 g.cm

Dynamic torque

$$2.8 \times \frac{6}{2} + 3.2 \times \frac{6}{2} = 18 \text{ cm g.cm}$$

Static unbalance

3.2 - 2.8 = 0.4 g.cm.

e) Balancing of inducer-impeller assembly

Tolerance : static unbalance $\leq$ 1.g.cm.

dynamic torque $\leq$ 20 cm.g.cm

To balance the assembly proceed as follows :

. on inducer : remove material from the convex side of vanes, while keeping within the limits specified for the impeller vane thickness.

. on impeller : remove material from the balancing land. See plate 8

30.3.2. Turbine

Standard turbine

The turbine assembly consists of :

- the turbine disc
- the blades
- an anti-vibration wire (if used)
- the blade locktabs

a) Visual inspection - (see plate 5)

- Inspect the assembly :
Inspect the anti-vibration wire (if used on the turbine) for condition : no kinks are permissible; the wire ends must be in good condition and bent up at an angle of about 30° (see detail A)

1. Blades

Inspect the blades for general condition : bent corners, impact marks, cracks, distortion, wear due to rubbing in the nozzle ring.

Bent corner

- one corner bent by 1 mm over 5 mm in length (i.e. along blade height) is acceptable - see detail B.

Impact marks

- one impact mark 0.7 mm deep is permissible - see detail C.

IMPORTANT : A blade showing an impact mark and a bent corner shall be systematically changed - see detail D

Carefully examine the trailing edge; impact marks with sharp corners likely to cause cracks are not acceptable.

Cracks :

- carry out a dye penetrant inspection. Use the penetrants provided for that purpose (section 70). No crack allowed.

Wear

- Some wear of the blade tip is acceptable provided that no cracks are revealed by the dye penetrant inspection, balancing requirements are met and clearance X is within the specified limits.

Check that blade roots do not protrude from the disc faces.

Inspect the blade locktabs on the disc for condition. Locktabs with damage marks or slightly straightened up should be replaced.

NOTE : If they need to be replaced 1 mm thick locktabs shall be replaced by locktabs 1.2 mm thick. The replacement of only one 1 mm thick locktab requires that all other locktabs of same thickness be replaced by 1.2 mm thick locktabs.

Examine the blade "fir-tree" roots and end faces : scratches not exceeding 0.05 mm in depth are acceptable.

2. Turbine disc

- Examine the disc for general condition :
  - signs of rubbing on the labyrinth seal lips
  - scratches on the faces of the disc rim, between the "fir-tree" grooves: scratches not exceeding 0.05 mm in depth are acceptable.
- Inspect the bore and splines for general condition (distortion, wear, twisting). Use the splined plug gauge provided.
- Check that the bush is not loose (tight fit).

b) Dimensional check

- Check there is no blade circumferential movement "M" (blades are a tight fit in the disc)
- If signs of rubbing have been noticed check the diameters "H" and "L" of the turbine labyrinth seal at 8 points.
- If wear marks are noticed in the disc bore, check the diameter "D".

c) Balancing check

The replacement of the anti-vibration wire, blade locktab and blade requires re-balancing of the turbine. To replace the above parts proceed as follows : anti-vibration wire:

- mark the two blades on the turbine between which the bent ends of the wire are positioned,
- change the wire taking into account this position and the arrangement of the wire ends (bent at an angle of 30°)

Blade locktab - See note in para. 1 "blades".

Blades - see para 4.1.3.2

If, too many parts need be changed on the turbine assembly it is recommended to replace the complete turbine assembly.

The turbine assembly shall be checked for balance after any rectifications or replacement of :
- anti-vibration wire
- lock tabs
- blades

Balancing of the turbine is effected with :

- All the blades fitted, locked by the tabs and pushed forward, i.e. in the direction LEADING-EDGE ⟶ TRAILING EDGE
- dynamic torque $\leq$ 20 cm.g.cm.

NOTE : To correct balance
- remove material from the balancing land "N" on the disc up to a maximum depth of 3.5 mm - (see plate 8)

If the operator has no balancing machine the turbine assembly shall be returned to the manufacturer who will carry out repair and balancing.

Turbine with integral blades

a) Visual inspection

1. Blades

Inspect the blades for general condition : cracks, bent corners impact marks, distortion, wear due to rubbing in the nozzle rings.

Cracks :
- carry out a penetrant inspection using the penetrants provided for that purpose (section 70). No cracks are permissible.

Bent corners
- one corner bent by 1 mm over 5 mm in length per blade is permissible - see detail B.

Impact marks and distortion
- one 0.7 mm deep impact mark or distortion per blade is permissible see detail C

IMPORTANT : Any turbine with more than 15 blades, whether equally spaced or not, showing at the same time bent corners and impact marks is not acceptable.

Wear
- some wear of the blade tip is acceptable provided that no cracks are revealed by the dye penetrant inspection, balancing requirements are met and clearance X is within specified limits.

Carefully examine the trailing edge : impact marks with sharp corners likely to cause cracks are not acceptable.

2. Turbine disc

Examine the disc for general condition :

- signs of rubbing on the labyrinth seal lips
- condition of bore and splines : distortion, wear, twisting are not acceptable. Use the splined plug gauge provided
- check that the bush is not loose (tight fit).

b) Dimensional check (see section 60)

- If signs of rubbing are noted check the diameters "H" and "L" of the turbine labyrinth seal at 8 points.
- If wear marks are noted in the disc bore, check the diameter "C"

c) Balance check

As no part is removable the balance check shall be carried out only if a large number of blades have to be rectified in accordance with instructions in para. 40.1.3.2.

dynamic torque $\leqslant$ 20 cm.g/cm

To balance the turbine rework the disc as shown in plate 8. (balancing lands P1-P2-P3).

30.4. SHAFT ASSEMBLY

30.4.1. Shaft

a) Visual inspection

- Inspect the journal surfaces and collar faces (thrust bearing) : surface scratches are acceptable within the following limits
  - 1 or 2 scratches, 0.05 to 0.10 mm deep.

  NOTE : Areas showing a blue colour are an indication of local overheating.
- Inspect the turbine and impeller locating diameter surfaces
- Inspect the splines and threads for condition : no twisting, no excessive wear.
- Inspect case hardened surfaces i.e. journal surfaces and collar faces, by magnetic particle process.

b) Dimensional check (section 60)

- check journal diameters "A"
- check the shaft collar thickness "E"
- with the shaft mounted between centres, check the concentricity of diameters.
  They shall be concentric to within 0.01 mm – 0.02 mm (total indicator reading)

  IMPORTANT : The collar faces must run perfectly true.

30.4.2. Bearing assemblies and labyrinth seals

A bearing assembly comprises :

- a bearing sleeve
- a sleeve housing
- a lock pin

a) Visual inspection

Bearing sleeves and housings

- check that the sleeve is not loose in its housing
- examine the sleeve bore for :
  - scratches
  - babbitt metal flake off
  - embedding of particles

  evenly distributed surface soratches are acceptable, no gaps in the babbitt metal layer (due to pick-up or wear) shall be accepted; embedded steel particles liable to score the shaft are not acceptable.

  NOTE : Depending of the condition of the bearing sleeve either the sleeve alone (see para.40.1.4.4.) or the complete bearing assembly shall be replaced.

Inspect the sleeve housing for :

- condition of tapped holes in front bearing
- condition of the bore for the sleeve (if the sleeve is to be removed - see para. 40.1.4.4.)
- cleanliness of the O'ring seal groove
- condition of locating diameter surface and face of flange mating with the exhaust casing,
- condition of lock pin hole
- condition of rear bearing labyrinth seal.

NOTE : ovality is unacceptable.

Inspect the lock pin
- replace any lock pin showing peening marks

Inspect oil holes and groove for cleanliness

Labyrinth seals

- check the grooves for cleanliness
- check that there are no shock marks on the faces

NOTE : A few light shock marks in the grooves are acceptable

- check that there is no distortion

NOTE : Any appreciable distortion is unacceptable.

b) Dimensional check (see section 60)

If signs of rubbing are noted check :

- the bearing sleeve bore diameter "A"
- the turbine labyrinth seal inner diameter "G"
- the bearing labyrinth seal inner diameter "L"

If the sleeve is loose in its housing check :

- the bearing housing inner diameter "F"

30.4.3. Thrust bearing assembly

The thrust bearing assembly consists of :

- a spacer
- clamp plates
- thrust washers
- locating spring pins or dowels

a) Visual inspection

Spacer

- Inspect
  - the faces for surface condition : no shock marks
  - dowel or spring pin holes for condition.

Clamp plates

Inspect
- the dowel or spring pin holes for condition
- the faces for surface condition :
  - scratches : very shallow scratches are tolerated.
  - shock marks: no shock mark in the areas of contact with the thrust washers is acceptable.
- on chrome plated clamp plates, check the chrome plate for flake-off : which is not acceptable.

NOTE : Clamp plates are interchangeable but not reversible.

- interchange the turbine side clamp plate and compressor side clamp plate, fitting them so that sound faces are used.

Thrust washers

Inspect
- both thrust washers for surface condition especially the lead-plated faces of the "compressor side" thrust washer.
- surfaces scratches are tolerated if very shallow.

NOTE : The thrust washers are reversible but not interchangeable. On friction faces of the "compressor side" thrust washer the absence of leadplate is an indication of wear as materialized by a clear area.

b) Dimensional check

Spacer
- no dimensional check is required

Turbine side thrust washer
- refer to the table of Fits and Clearances, section 60

Compressor side thrust washer
- using a ruler measure the dimension "a" between two points taken on the intermediate circumference and on the edges and delimiting the clear area of wear - see plate 8, ref. No 8.

If a $>$ 8 mm - Reject the washer

30.4.4. Miscellaneous parts

a) Bolts

- inspect the threads for condition : distortion, stripping, corrosion.

b) Impeller and turbine retaining nuts
- inspect the threads and wrench slots for condition : distortion, stripping, corrosion.
- inspect the faces for good condition
- smooth down any marks on nut faces.

c) Adjusting washers
- inspect the faces for good condition
- smooth down any marks found on the faces

NOTE : Washers with deep marks shall be changed.

d) Oil deflector ring
- inspect the faces for surface condition
- smooth down any shock marks

e) Seals, gaskets and tabwashers (except turbine lock tabs)
- replace them systematically.

30.4.5. Checking the oil flow to the bearings

After reassembly of the shaft and bearings check that oil circulates and measure the oil flow to the bearings.

- use normal lubricating oil
- test pressure : 1.5 bars
- oil flow to bearings : 0.800 to 0.900 litre in 30 seconds.

Procedure

- to the oil inlet connection on the gas exhaust casing connect a pipe fitted with a pressure gauge and connected to an oil pressure source
- apply pressure for some time to fill the system until oil flows out from the bearings
- place drip receiving cups, connected to a measuring cylinder, at the shaft outlets under the oil labyrinth seals of the bearings and at the oil return connections of the exhaust casing
- apply an oil pressure of 1.5 bars for 30 seconds
- record the amount of oil collected in the measuring cylinder.

40

REPAIR - PROTECTIVE TREATMENT

40. REPAIR - PROTECTIVE TREATMENT

40.1. REPAIR

40.1.1. Exhaust gas system

40.1.1.1. Gas intake casing and casing spacer

a) Rectifications by hand

- Smooth out shock marks, impact marks or damage marks by filing or careful polishing with emery cloth to restore flatness.
- Fit wire thread inserts in damaged tapped holes
- Change loose or damaged studs.

b) Rectifications by machining

Rework the nozzle ring locating diameters if out-of-round or deeply marked.

NOTE : Other repair operations that may become necessary will be indicated later.

40.1.1.2. Turbine nozzle

a) Rectifications by hand

1. Rings

- Smooth out shock or impact marks by stoning or careful polishing with emery cloth to restore the surface condition.
- Deburr any peening marks in the vane locating slots.

2. Nozzle guide vanes

- Smooth out impact marks on leading edge or in aerofoil section by stoning or careful polishing with emery cloth, taking care to maintain the vane profile.
- Deburr peening marks on the vane platforms
- Straighten bent edges
- After straightening an edge, carry out a dye penetrant inspection with the penetrants provided for that purpose (section 70)

NOTE : Any incipient crack on a vane calls for the rejection of the vane.

IMPORTANT : If a vane shows impact marks together with a bent edge it shall not be rectified but replaced by a new vane.

b) Rectifications by machining

1. Rings

- Restore, to true round shape, rings that are out-of-round
- Rework the vane locating slots that are deeply marked due to vane fluttering.

2. Vanes

- No rectification by machining is considered.

NOTE : Other repair operations that may become necessary will be indicated later.

40.1.1.3. Gas exhaust casing

a) Rectifications by hand

- Smooth out shock and impact marks by scraping and careful polishing with emery cloth
- Change dowel pins showing damage marks
- Change the plugs that are leaky
- Tightening torque - plug P/N 6766 = 15 m.daN
  - plug P/N 6765 = 20 m.daN

NOTE : When fitting new plugs use the sealing compounds provided (section 70) to perfect the sealing.

- Fit wire thread inserts in bearing securing bolt holes to permit the use of standard size bolts.

b) Rectifications by machining

- Fitting of threaded inserts to permit the use of standard size bolts and studs (see para. 80.2.2)
- Possible fitting of oversize plugs if threads in the casing are damaged.

NOTE : Other cases of rectification by hand or machining may be considered later.

40.1.2. AIR INTAKE SYSTEM

40.1.2.1. Compressor casing

a) Rectifications by hand

- Smooth out shock and impact marks by careful stoning or polishing with emery cloth
- Change loose studs (see para. 80.2.2)
- Replacement or refitting of threaded inserts. If threads in the casing are in good condition, refit the inserts after having coated their threads with loctite - see section 70 - otherwise fit oversize inserts - see para.80.2.2
- Replacement or refitting of "helicoil" wire thread inserts

b) Rectifications by machining

- If necessary clean up light rubbing marks

NOTE : Other special cases of rectification by hand or machining may be considered later.

40.1.2.2. Diffuser

a) Rectifications by hand

- Smooth out shock and impact marks by careful stoning or polishing with emery cloth.
- Diffuser vanes :
  - remove possible impact marks on the leading edge by carefully blending with a radius.

    NOTE : Maximum permissible number of impact marks per vane.
    - 1 impact mark 1 mm deep.

  - smooth down impact marks situated on the vane surfaces
- Smooth out marks caused by tie-bolt heads.
- Locally protect the reworked areas - refer to para.40.2

b) Rectifications by machining

If necessary rework the counterbores for tie-bolt heads.

NOTE : Other special cases of rectification by hand or machining may be considered later.

40.1.2.3. Diffuser cover

a) Rectifications by hand

- Smooth out :
  - possible peening marks due to the diffuser vanes
  - any shock marks on surfaces and labyrinth seal lips by stoning or careful polishing with emery cloth.

b) Rectifications by machining

No rectification by machining is considered for the cover.

NOTE : Other special cases of rectification by hand or machining may be considered later.

40.1.3. ROTATING ASSEMBLY

40.1.3.1. Impeller

a) Rectifications by hand

Impact marks on inducer
- on vane leading edge (see plate 4)

- Tolerance per vane :
  - 1 impact mark with a maximum depth of 1 mm
  - 2 impact marks, each with a maximum depth of 0.7 mm.
- Smooth down these impact marks by blending carefully with a radius to a depth-to-length ratio of 1 to 20 mm. taking care to restore the original profile by filing and then polishing with fine emery cloth.
- For marks in the middle of the vane surface, deburr and smooth down following the vane profile
- On the trailing edge of the impeller vanes :
  - smooth out shock and impact marks by polishing with fine emery cloth.
- Labyrinth seal
  - smooth out impact marks taking care to maintain the curvature.

NOTE : Impact marks shall not show any incipient cracks

b) Rectifications by machining

- If necessary re-machine the locating dowel holes.

NOTE : This re-machining can only be carried out in workshops specially equipped for this operation.

- Replace the impeller and inducer bushes if necessary.
- Rework by machining any impeller and inducer that have rubbed on the casing.

40.1.3.2. Turbine

a) Rectifications by hand

- Smooth out impact marks on the blade leading edge and aerofoil section by careful stoning and polishing with fine emery cloth.
- Smooth out shock and impact marks on the turbine discs.
- Smooth out rubbing marks on the labyrinth seal lips.
- If necessary replace the anti-vibration wire.

b) Replacement of blades and locktabs on standard turbines

The number of blades or locktabs replaced is not limited

NOTE : When replacing blades the difference in their weight must not exceed 0.02 g.

c) Rectification by machining

- Rework the sealing rim of any disc showing rubbing marks (no deeper than 0.5 mm).

NOTE : Other special cases of rectification by hand or machining may be considered later.

40.1.4. SHAFT ASSEMBLY

40.1.4.1. Shaft

a) Rectifications by hand

- Smooth out scratches with crocus cloth within the limits of minimum diameter A - B - C (see section 60)
- Smooth out shock marks by careful stoning.

b) Rectifications by machining

- Chronium plate the journal diameters of the shaft

NOTE : This operation can only be carried out in workshops with appropriate facilities and by people experienced in this kind of work.

40.1.4.2. Bearing assemblies

a) Rectifications by hand

Bearing housing
- smooth out marks on locating diameter and flange faces
- if necessary, replace the damaged bearing - see para. 1.4.4.

Labyrinth seals
- smooth out shock marks on the flange faces

b) Rectifications by machining

- no rectification by machining is considered for the bearing assembly.

NOTE : Other special cases of rectification by hand or machining may be considered later.

40.1.4.3. Thrust bearing assembly

a) Rectifications by hand

Spacer :

- smooth out shock marks by careful stoning

Clamp plates

- smooth out shock marks on the faces by stoning
- smooth out possible surface scratches by polishing with crocus cloth

Thrust washers

- no rectification by hand is presently considered

b) Rectifications by machining

Spacer :
- no rectification by machining is presently considered

Clamp plates
- remove deep score marks by grinding

Thrust washers
- no rectification by machining is presently considered

40.1.4.4. Replacement of a front or rear bearing sleeve

a) Special equipment

- workshop press, 5-ton minimum capacity
- heating furnace capable of a temperature of 200°C
- liquid nitrogen to shrink the bearing sleeve

b) Special tools (see para.80.1.1.)

c) Disassembly (see plate 6)

- remove the bearing sleeve lock pin
- place the bearing housing in the recess of extractor 926-78 corresponding to the front or rear bearing as appropriate.
  The bearing housing should be in correct position for pressing out the sleeve
- fit the mandrel in the sleeve bore
- press out the sleeve (workshop press.)

d) Inspection and check of bearing housing bore

- If necessary, smooth out any "press-out" marks on the sleeve by polishing with fine emery cloth
- check bore diameter "F" (see section 60)

NOTE : If the diameter "F" measured is greater than the maximum dimension given in section 60 - it will be possible to bring back the bore diameter to new part dimension by chromium plating.

e) Reassembly - see plate 6

- heat the bearing housing to 180-200°C maximum
- fit the bearing sleeve onto the mandrel No 920-30 taking into account the 22 mm dimension, distance of the locating hole from one end of the sleeve.
- turn in the knurled head screw (2) of the mandrel so that the pin (1) engages the sleeve hole but is underflush from the sleeve outside diameter surface.
- immerse the sleeve and mandrel assembly in a tank containing liquid nitrogen
- place the heated bearing housing on the front bearing support block 92010-78 or rear bearing support block 92020-78 as appropriate
- line up the lock pin hole in the bearing housing with the axis of the guide key (3) in the support block.

- insert the mandrel-bearing sleeve assembly in the bearing housing and support block
- allow the bearing-sleeve assembly, mandrel and support block to stand until they are at room temperature
- turn out the screw (2) of the mandrel and withdraw the mandrel from the bearing.

CAUTION : The inner end face of bearing sleeve (on support block side) must be underflush from the bearing housing face.

- once the bearing reassembled
- check that :
  - the lockpin properly engages the bearing sleeve hole. (lightly underflush from the bore surface)
  - sleeve bore diameters are within tolerance limits - see diameters A and B.

40.2. PROTECTIVE TREATMENTS

Refer to section 70

NOTE : The protective materials to be used are identified in the following paragraphs by their reference number in the Table of Materials.

40.2.1. Protection of new parts

a) The following parts are protected by chromic anodizing (see table of materials)
   - compressor casing, air annulus wall
   - compressor cover
   - inducer and impeller, external part and vanes
   - diffuser

b) Protect the following parts
   - bolts and studs (materials No 2-3-4-5)
   - shaft splines (materials No 5 and 6).

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ASSEMBLY

50. ASSEMBLY

CAUTION

Assembly recommendations

- a new shaft requires to be fitted with new thrust washers
- a shaft, No 6456, must be fitted with front bearings P/N 6458.
- if new thrust washers are fitted, it is recommended to interchange the clamp plates so that faces in good condition are in contact with the thrust washers.
- pay attention to the difference between compressor side thrust washers and turbine side thrust washers especially in the case of early type compressor side thrust washers of smaller diameter.
- never fit a compressor side thrust washer of large diameter (56 mm dia.) on a shaft with a small diameter collar (52 mm dia.)

50.1. ASSEMBLY PROCEDURE - Plate 1

a) Lubrication

b) Preparation of assemblies

c) Installation of shaft assembly - check of thrust bearing clearance.

d) Installation of rear bearing

e) Installation of compressor impeller - (check and if necessary adjustment of functional clearance)

f) Installation of compressor casing

g) Installation of turbine (check and, if necessary, adjustment of functional clearances)

h) Installation of nozzle casing

(i) installation of intake duct

50.1.1. Lubrication

Refer to the table of Materials, section 70 to find the lubricant to be used, as identified below by a reference number.

- Lubricate the following parts (Lubricant No 10)
  - thrust washers
  - bearing sleeves
  - shaft journals and collar.

50.1.2. Preparation of assemblies

a) Shaft, check and adjustment of thrust bearing clearances.

- Fit the spring pins (14) or dowel pins into the front bearing (15) (detail A)
- install the first clamp plate (13)
- fit the thrust washers (10) (11) on the shaft on each side of the collar.

IMPORTANT NOTE : The thrust washer (10) with large outside diameter shall be fitted on the compressor side of the shaft collar.

- insert the shaft in the front bearing
- install the spacer (12)

NOTE : The spacer can be fitted in either of two positions one of which is to be preferred.

Best fitting position :

Two of the three oil return holes must be positioned downwards i.e. below the horizontal plane.

- The other position, however does not adversely affect the functioning of the turbocharger; in that case the oil inside the assembly reaches a higher level.

- fit the second clamp plate (13), locating it on the spring pins
- fit the spring pin retaining plate (19)
- fit the bolts (20) provided with their tabwashers (21)

NOTE : Do not lock the bolts with the tabwashers until the thrust bearing clearance has been checked.

Check the thrust bearing clearance (see table of Fits and Clearances, section 60)

- mount a dial indicator with 0.01 mm division, securing it through one of the bearing bolt holes
- clamp the assembly on the bearing
- push on the shaft to make its collar butt against the "turbine side" thrust washer (11)
- apply the dial indicator contact point to the compressor end of the shaft and set the dial to zero
- pull on the shaft to make its collar butt against the "compressor side" thrust washer.
- the reading obtained on the dial indicator is the thrust bearing clearance
- remove the dial indicator
- lock the bolts (20) by means of the tabwashers (21)

b) Assembly of gas intake casing and spacer (65)

- fit a gasket (64) to the casing
- position the spacer (65) on the casing
- fit the bolts (69), nuts (71) and tabwashers (20)
- tighten and lock the nuts

c) Nozzle assembly

- partly insert the outer ring (73) in the casing (62) or spacer (65) interposing three distance pieces and the securing bolt holes being lined up.

- position two diametrically opposed vanes in the ring so that their leading edges coincide with two partitions of the casing.
- remove the distance pieces and allow the ring to rest on the casing
- position the inner ring on the vanes so that the securing bolt holes are lined up. (only one position is possible)
- mark the relative position of the rings on the casing with a grease pencil or marker.
- remove the ring assembly and fit all the vanes one by one.
- install the assembly in the casing in the same position as indioated by the marks previously made.
- lightly smear the bolts (77) with molyslip grease (lubricant No 5)
- secure the nozzle assembly with the bolts and tabwashers (76)
- check and if neoessary adjust the nozzle area - see para. 50.1.10.

d) **Assembly of diffuser**

1) Diffuser (85 detail B) secured with countersunk head screws.

Determine the thickness n of shims to be fitted to obtain the required "nip" of the diffuser between the diffuser cover and compressor casing - see section 60 - nip - "V".

Procedure

- Measure the distance from the compressor casing joint face to the diffuser vane face that mates with the inner face of the diffuser cover (84) (dimension x1)
- measure the depth of the diffuser locating recess in the compressor oasing (dimension y1)

NOTE : For these two measurements use a depth gauge.

- measure the thickness of the diffuser (dimension z1) with slide callipers at 1/50 mm.
- calculate the thickness n of shims to be fitted to obtain the nip "V"

$$x^1 + y^1 - z^1 = n \ (+ \text{ value of } V)$$

NOTE : Allowance should be made for the squeezing of the shims (82) occurring when the screws securing the diffuser to the compressor casing are tightened.

Fitting

- fit the shims (108) of the appropriate thickness
- locate the diffuser inside the compressor casing (101)
- fit and tighten the screws (109)
- lock the screws by peening some material of the diffuser in the screw head slots

2) Diffuser (85) secured with tie-bolts

- place the diffuser on the cover (84)
- fit the tie-bolts in their holes
- fit a plain washer (87) on the bolt
- fit the nuts (88) screwing them finger tight
- locate the diffuser and cover on the compressor casing (101)
- in this position finally tighten the nuts (88)
  Torque load : 0.10 to 0.12 m.daN

NOTE : Do not fit a tie-bolt P/N 6489 with a nut P/N 400481 or a tie-bolt P/N 53460 with a nut P/N 6509 as the pitch of their threads is different.

50.1.3. Refitting the shaft assembly

- Fit the O'ring seal (22) in the groove on the bearing (15)
- smear the faces of gasket(23) with sealant No 23 (see section 70) and fit it on the bearing
- fit the gasket (24)
- fit the oil seal (25) to the bearing
- progressively and evenly screw and tighten the bolts (27) provided with their tabwashers (26)
- bend up the washer tabs.

50.1.4. Refitting the rear bearing (31)

- Fit the O'ring seal (28) in the groove on the bearing
- smear the faces of gasket (29) with sealant No 23 (see section 70) and fit it on the bearing
- fit and align the bearing in the exhaust casing and on the shaft
- take care to see that oil and air holes are correctly positioned
- fit the deflector ring (34) on the shaft with the chamfer outward
- install the gasket (35) on the rear bearing
- locate the labyrinth seal (36)
- screw and tighten the bolts (39) fitted with their tabwashers (37-38)
  Torque loading : 2.5 to 2.7 m.daN.
- bend up the double tabwashers

NOTE : Check the shaft for free rotation
After the shaft and bearings have been refitted check the oil flow to the bearings - see section 30, para.30.4.5.

50.1.5. Refitting the impeller (90) - check and adjustment (if necessary) of clearance Y (see section 60)

NOTE : This clearance is obtained by varying the total thickness EE of a number n of adjusting washers (98) of known thickness.

Checking the clearance Y (see figure 8)

- fit the same number of adjusting washers (98) into the impeller bush as was removed at dissassembly.

- slide the impeller fully on to the shaft until the washers butt on the shaft shoulder

IMPORTANT : Ensure that the inducer (rotating guide vanes) bush is not butting against the first shoulder of the shaft which would prevent the clearance between the impeller and compressor casing from being controlled solely by the adjusting washers.

- install the compressor casing (101) and secure it with three nuts (112) spaced at 120°
- pull on the shaft to make its collar butt against the thrust washer on the compressor side
- mount a dial indicator with 0.01 mm divisions on the compressor casing, so that its contact point bears on the impeller nut seating face on the inducer
- set the indicator to zero
- pull on the compressor impeller until its vanes contact the internal wall of the volute
- the dial indicator reading gives the existing clearance between the impeller and compressor casing.
- the clearance must be within the limits given in the table of fits and clearances, section 60, clearance "Y".

In case of incorrect clearance proceed as follows

Clearance smaller than the minimum :
- reduce the thickness of washers by removing a number n of washers (98) to obtain the correct clearance.

Clearance greater than the maximum :
- increase the thickness of washers by adding a number n of washers (98) to obtain the correct clearance.

After determining the clearance

- remove the dial indicator
- remove the compressor casing (101)
- fit the tabwasher (99)
- fit and tighten the impeller retaining nut (100)
- tighten to a torque of 8 m.daN $\pm$ 1
- use the spanners 927/78 and 928/78

50.1.6. Refitting the compressor casing

- smear the joint face with jointing coumpound - Table of materials, section 70 - sealant No 23
- install the O'ring seal (110) (diffuser secured with tie-bolts)
- install the compressor casing (101) with outlet flanges in correct angular position and secure with nuts (112) and lock-washers (111)
- check the rotating assembly for free rotation by hand.

50.1.7. **Refitting the turbine**

- Every time a turbine is refitted, the blade tip clearance "X" and the clearance "J" between the turbine disc and the nozzle inner ring must be systematically checked and adjusted if necessary, (see section 60)

1. Turbine fitting preparatory to check of clearance "X"
   - fit the adjusting washers (50)
   - slide the turbine on to the shaft
   - fit the tabwasher (58)
   - screw and tighten the nut (59)
   - tightening torque : 16 m.daN ± 2
   - use the spanners 927/78 and 928/78

   NOTE : Do not lock the turbine nut as it may be necessary to remove it after the check

   - fit the gasket (79) on the gas intake casing joint face
   - install the turbine nozzle assembly (60) locating it on the dowel pins (80)
   - fit and tighten three bolts (82) spaced at 120°

2. Determining the blade tip clearance

   To adjust the blade tip clearance, push the shaft to make its collar butt on the compressor side thrust washer.
   Access to the turbine is gained through the upper face of the gas exhaust casing.

   a) Finding the longest blade
      - using a set of feeler gauges measure the clearance between the tip of each blade and the outer ring (73) at a same point on the ring, by rotating the turbine by hand,
      - mark the longest blade i.e. that with minimum tip clearance This blade "AA" will be used to determine the functional tip clearance "X"

   b) Checking the functional tip clearance "X" on turbochargers fitted either with tapered blades or parallel blades (see section 60).
      - using the set of feelers, measure the clearance between the longest blade "AA" and the outer ring (73) at 8 equally spaced points in order to take into account any possible distortion of the nozzle rings.
      - select as the actual tip clearance the smallest value obtained between a point "BB" on the outer ring and the blade "AA".

   c) Functional tip clearance on turbochargers fitted with tapered blades (5° or 10° taper)
      - a first measurement will give the observed clearance J1. The difference between the observed clearance J1 and the clearance to be obtained J0 is $\Delta J = J1 - J0$. Let ΔEE be the variation of the total thickness of adjusting washers of known thickness necessary to obtain a variation ΔJ of the turbine blade tip clearance (see table below for determining the clearance).

TABLE FOR DETERMINING THE BLADE TIP CLEARANCE AND CALCULATION OF TOTAL THICKNESS OF ADJUSTING WASHERS

X	Functional tip clearance (see section 60)
J1	Observed clearance
J0	Clearance to be obtained
ΔJ	J1-J0 or J0-J1
EE	Total thickness of adjusting washers
5.75 (turbine with 10° taper) 11.50 (turbine with 5° taper)	Thickness calculation factor to be added or subtracted from EE
ΔEE	ΔJ x 5.75 or 11.50
(*) negative EE	Reduce EE by : EE - ΔEE
(**) positive EE	Increase EE by : EE + ΔEE

(*) negative EE	Total thickness of adjusting washers too great (clearance J1 < minimum clearance)
(**) positive EE	Total thickness of adjusting washers too small (clearance J1 > maximum clearance)

Examples of calculation of EE (in mm) for a turbine with 10° taper.

a) negative EE

J0 = 0.55 ± 0.15
J1 = 0.25 (< 0.55)
ΔJ = 0.55 - 0.25 = 0.30
ΔEE = 0.30 x 5.75 = 1.725 or 1.73
EE = negative EE - 1.73
Therefore reduce the thickness (negative EE) of adjusting washers by 1.73

b) positive EE

J0 = 0.55 ± 0.15
J1 = 0.75 (> 0.55)
ΔJ = 0.75 - 0.55 = 0.20
ΔEE = 0.20 x 5.75 = 1.15
EE = positive EE + 1.15
Therefore increase the thickness (positive EE) of adjusting washers by 1.15

NOTE : For a quick determining of ΔEE from ΔJ use the diagrams shown in figure 7. Diagram A : turbine with 5° taper
Diagram B : turbine with 10° taper

d) Functional tip clearance on turbochargers fitted with parallel blades (see section 60)

- measure the clearance between the longest blade "AA" and the outer ring at point "BB" (see section 50, para.50.1.7a and b.
- if the clearance is incorrect, grind the outer ring the required amount to obtain the functional clearance.

e) Check and if necessary adjustment of clearance "J" between the turbine disc and the inner ring - see table of fits and clearances, section 60.

NOTE : The check and adjustment of this clearance shall be carried out at the same time as the check and adjustment of clearance "X".

- This clearance will be checked using three gauges to be made up locally as indicated in section 80.
- passing the hand through the opening on the top face of the gas exhaust casing insert the short bent end of each gauge in turn between the turbine disc and the inner ring.
  - the 1 mm gauge must go with little clearance
  - the 1.2 mm gauge must go without clearance
  - the 1.5 mm gauge must not go
- if necessary, obtain the correct clearance by varying the number n of adjusting washers (50)

CAUTION : In obtaining this clearance take clearance "F" into account. Blade tip and turbine disc clearance ranges are wide enough to enable correct clearances to be obtained.

- after the turbine functional clearances have been checked and the total thickness of adjusting washers (50) to be interposed behind the turbine has been determined :
  - remove the turbine nozzle assembly (60)
  - remove the turbine (51)
  - remove the adjusting washers
  - remove or add the number n of adjusting washers necessary to obtain the required thickness.

f) Finally refit the turbine

- fit the adjusting washers (50) on the shaft
- install the turbine engaging its splines with those of the shaft
- install the tabwasher (58)
- fit the nut (59), with the chamfer facing the turbine disc
- tighten the nut. Torque : see para. 50.1.7.1
- lock the nut by bending the washer tab, taking care that it does not show a sharp edge which would promote breaking.

50.1.8. Refitting the turbine nozzle assembly

- fit the gasket (79) to the gas intake casing (62)
- install the nozzle assembly (60) with the gas inlet flanges in correct angular position.
- fit the bolts (82) provided with their tabwashers (81). Tighten the bolts to a torque of 4 - 4.5 m.daN
- bend up the washer tabs
- check the rotating assembly by hand for free rotation

NOTE: If bolts with drilled heads are used, lock with locking wire.

50.1.9. Refitting the air intake duct

- on each bolt (127), fit a lockwasher (128) and a plain washer (129)
- position the intake duct (126) on the compressor casing
- fit and tighten the securing bolts

50.1.10. Check and adjustment of turbine nozzle area (see plate 9)

A. Definition of nozzle area

1) This area is indicated by the last 2 or 3 figures of the turbocharger specification engraved on the name plate. These figures represent the value of the area in square centimeters.

Example : HS 419 Bx1 17.5 p. 6.5 M 86. Here the nozzle area is 86 sq.cm.

2) The turbine is defined by the last figure of the first number of the specification.

Example : HS 419. The figure 9 characterizes the turbine nozzle series.

B. Method of measurement of nozzle area

The throat area between two adjacent nozzle guide vanes is represented by the surface area of a right-angled trapezium (see figure A) L being the radial length of the throat. This throat area is the same in all turbocharger versions fitted with a nozzle of a same series : 0 - 6 - 8 or 9.

The length L in mm is given in the table below.

Nozzle series	Length L	Dimension $A = \frac{L}{2}$
0-8	41	20.5
6	36	18
9	46.3	23.15

The dimension $l = \frac{a + b}{2}$ is the mean width of the throat. It is peculiar to each throat and is determined as described in para.D

The check consists in measuring the actual dimension l of each throat and calculating the average dimension for the whole nozzle. The total nozzle area "S" is then obtained as follows.

S = mean width (l) x length (L) x number of throats.

C. Necessary tools : (see para. 80.1.4 and plate 9)

D. Check procedure

1) Setting the INTRAMESS checking tool

a) Calculate the value of nominal dimension $l = \frac{S}{NxL}$

where S, is the specified nozzle area (as read on the nameplate)

N, is the number of throats (or number of vanes, i.e.75)

L, is the length of throat as given in the table in para.B

b) Set and lock a micrometer to the dimension l found.

c) Insert the split ball-end of the checking tool between the micrometer anvil and spindle and set the dial indicator of the tool to zero. Note the position of the small pointer of the indicator.

c) Withdraw the checking tool ball-end from the micrometer. The dial indicator pointer then moves to any position.

2) Setting the ball-end centralizing tool

a) Calculate the value of $C = B + \frac{D}{2} - A$, where B is the width of the centralizing tool.

A is the dimension $\frac{L}{2}$ given in the table in para.B.

D is the width across flats of the split ball-end (J) of the checking tool.

b) Pile up Johnson gauge blocks on a surface plate to obtain a total thickness equal to the value of C.

c) Position the centralizing tool against a box plate so that the edge F of the tool rests on the surface plate.

d) Bring the adjustable contact piece (G) in contact with the gauge blocks.

NOTE : A depth gauge set to the dimension C may also be used.

3) Measurement of vane throat areas

a) Mark all the vanes with a grease pencil or marker

b) Position the tools in each throat in turn as shown in plate 9 with :
- contact point (E) bearing against the outer ring (73)
- square lugs (H) bearing against one of the vanes (75)
- split ball-end (J) inserted in the throat and bearing against the contact piece (G)

c) In a table similar to that shown in para G enter the differences (in plus or minus direction) of each throat from the nominal width 1, that is from the zero division of the dial indicator (the zero division corresponds to the position of the small pointer - see para. D.1.c)

There may be three cases :

- pointer reading zero : 1 actual = 1 nominal (throat area is correct)
- pointer to the right of zero : 1 actual < 1 nominal (insufficient throat area)
- pointer to the left of zero : 1 actual > 1 nominal (excessive throat area)

If 1 actual - 1 nominal < 0.05 reduce the throat area

If 1 nominal - 1 actual < 0.05 increase the throat area

d) Effect the algebraic sum of differences noted and calculate the mean throat width of the nozzle

e) Calculate the total throat area of the nozzle

S = mean width x length L x number of throats.

E. Adjustment of throat area

If necessary adjust the throat area, using tool (M) or tool (K) respectively to reduce or increase the throat area in order to obtain the specified value shown on the nameplate.

NOTE : Total throat area limits : ± 1 sq.cm

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HS 400 TURBOCHARGER

F. Table showing, for each turbocharger type, the values (column 3) to be added to (+) or subtracted from (-) the theoretical nominal total area (column 4) given by new turbine nozzle components in order to obtain the corresponding specification value (column 1)

Turbocharger Specification		Serial No	Correction (+) or (-) sq.cm.	Theoretical nominal area sq.cm.	Turbine nozzle component part No		
					outer ring	inner ring	vanes
1		2	3	4	5	6	7
HS 400A2	17,5-5M71	0001	0	71	53.093	53.082	53.462
HS 406B1	11-5M52	1001	-4	56	53.094	53.081	53.463
HS 410E1	12p3M77	2001	+6	71	53.092	53.080	53.462
HS 410E1	11p3M71	3001	0	71	53.093	53.082	53.462
HS 416E1	12p6M52	4001	-4	56	53.094	53.081	53.463
HS 416E1	12p6M52	5001	-4	56	53.094	53.081	53.463
HS 416BF1	17,5p9M75	6001	-4	79	53.098	53.088	53.463
HS 416B2	17,5p10M61	7001	-4	65	53.096	53.086	53.463
HS 419B1	17,5p9M87	8001	+1	86	53.153	53.087	53.437
HS 419BX1	17,5p3M98	12001	-4	102	53.099	53.083	53.437
HS 418B1	17,5p7M74	13001	-6	80	53.106	53.086	53.451
HS 418B2	17,5p8M71	14001	-1	72	53.189	53.087	53.451
HS 419BX1	17,5p3M128,5	15001	-1,5	130	53.330	53.331	53.437
HS 419BX1	17,5p7M89	16001	0	89	53.440	53.086	53.437
HS 416B1	17,5p12M52	17001	-4	56	53.094	53.081	53.463
HS 418B1	17,5p8M74	18001	-6	80	53.106	53.086	53.451
HS 419BX2P	17,5p7M83	19001	-3	86	53.153	53.081	53.437
HS 416B2	17,5p11M58	20001	-7	65	53.096	53.086	53.463
HS 418BX2	17,5p7M77	21001	-8	85	53.109	53.084	53.451
HS 416B1	17,5p12M52	22001	-4	56	53.094	53.081	53.463
HS 419BX2	17,5p9A81	23001	0	81	53.436	53.081	53.437
HS 418B1	17,5p10M78	24001	-7	85	53.109	53.084	53.451
HS 419BX1	17,5p7M79	25001	-2	81	53.436	53.081	53.437
HS 419BX1	17,5p2M102	26001	-3	105	53.187	53.091	53.437
HS 419BX2	17,5p7,5A86	27001	-3	89	53.440	53.086	53.437
HS 419BX1	17,5p2M115	28001	-4	119	53.100	53.089	53.437
HS 416E1	12,5p9M55	29001	-1	56	53.094	53.081	53.463
HS 419BX1	17,5p6,5M86	31001	0	86	53.440	53.086	53.437
HS 418B1	17,5p6M83	33001	-3	85	53.108	53.083	53.451
HS 419BX1	17,5p4M97	34001	-5	102	53.099	53.083	53.437
HS 419BX2	17,5p3M98	35001	-4	102	53.099	53.083	53.437
HS 418B2	17,5p6,5M68	36001	-1	69	53.110	53.081	53.451
HS 416B1	17,5p13M63	37001	-4	67	53.188	53.084	53.463
HS 418BX2	17,5p7M80	38001	-3	83	53.107	53.085	53.451
HS 418B2	17,5p4M99	39001	+13	86	53.108	53.083	53.451
HS 419BX2P	17,5p7M86	40001	-3	89	53.440	53.086	53.437
HS 419BX1	17,5p4M94	41001	-4	98	53.104	53.085	53.437
HS 418BX2	17,5p6M77	42001	-8	85	53.109	53.084	53.451
HS 419BX1	17,5m6M83	43001	-3	86	53.153	53.087	53.437
HS 418BX2	17,5p6M77	44001	-8	85	53.109	53.084	53.451
HS 418B1	17,5p7M68	45001	-1	69	53.110	53.081	53.451
HS 419BX1	17,5p2M115	46001	-4	119	53.100	53.089	53.437

1	2	3	4	5	6	7
HS 419BX2 17,5p6M86	47001	-3	89	53.440	53.086	53.437
HS 419BX2 17,5p6,5A83	48001	-3	86	53.153	53.087	53.437
HS 418B1 17,5p9M74	49001	-6	80	53.106	53.086	53.451
HS 416BF1 17,5p13M53	50001	-3	56	53.094	53.081	53.463
HS 419B1 17,5p7A83	52001	+2	81	53.436	53.081	53.437
HS 416E1 13p10,5M48	53001	-8	56	53.094	53.081	53.463
HS 419B1 17,5p9M90	54001	+1	89	53.440	53.086	53.437
HS 418B1 17,5p6M80	55001	-5	85	53.109	53.084	53.451
HS 416B1 17,5p12,5M52	56001	-4	56	53.094	53.081	53.463
HS 416B1 17,5p13M52	57001	-4	56	53.094	53.081	53.463
HS 419B1 17,5p9M79	58001	-2	81	53.436	53.081	53.437
HS 418B1 17,5p9M93	59001	0	93	53.263	53.090	53.451
HS 418B1 17,5p9M81	60001	-4	85	53.109	53.084	53.451
HS 419BX2 17,5p6,5A86	61001	-3	89	53.440	53.086	53.437
HS 416B1 17,5p11M61	62001	-1	62	53.097	53.087	53.463
HS 418B1 17,5p8M81	63001	-4	85	53.109	53.084	53.451
HS 416B1 17,5p12,5M52	64001	-4	56	53.094	53.081	53.463

G. **Example** of table for recording the turbine nozzle throat areas

Difference of vane throats from nominal width 1.

Vanes Nos	-	+
1-2		
2-3		
3-4		
4-5		
5-6		
7-8		
8-9		
9-10		
10-11		
11-12		
12-13		
13-14		
14-15		
15-16		
16-17		
17-18		
18-19		
19-20		
20-21		
21-22		
22-23		
23-24		
24-25		
25-26		
26-27		
27-28		
28-29		
29-30		
30-31		
31-32		
32-1		
Total	-	+

Algebraic sum _____

Average of differences :

Algebraic sum / Number of throats = =

Mean width

Width 1 ± average of differences =

_____ ± _____ =

Mean throat area :

Mean width x length L =

_____ x _____ =

Total area :

Number of throat N x mean throat area =

_____ x _____ =

Total nozzle area in sq.cm.
S :

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FITS AND CLEARANCES

60 - TABLE OF FITS AND CLEARANCES

- Clearances given in mm. - see plate 8

Turbocharger unit serial No	INDEX No	Description of clearances and reference letters	NEW PART				WORN PART		REMARKS
			DIMENSIONS		CLEARANCES		Max. clearance	Reject dimension	
			MIN.	MAX.	MIN.	MAX.			
All HS 400 turbochargers	15 30	Front bearing with sleeve Rear bearing with sleeve - bore dia. A	38.500	38.530	0.120	0.161			
	9	Shaft - dia. A - dia. B	38.369 37.980	38.380 37.991	0.009	0.036			
	90	Impeller and bush assembly - bore dia. B	38.000	38.016					
	9	Shaft - dia. C	30.780	30.791	0.009	0.036			
	51	Turbine - bore dia. C	30.800	30.816					
	10 11	Thrust washers - thickness (turbine side washer) - clearance D	3.952	4.000	0.260	0.394		0.08 in excess of original clearance	The original clearance is marked on the engine logbook
	9	Shaft collar - Thickness E	4.982	5.000					
	15 30	Front bearing Rear bearing - bore dia. F	42.200	42.216					

Turbocharger unit serial No	INDEX No	Description of clearances and reference letters	NEW PART				WORN PART		REMARKS
			DIMENSIONS		CLEARANCES		Max. clearance	Reject dimension	
			MIN.	MAX.	MIN.	MAX.			
All HS 400 turbochargers	51 50	Turbine Adjusting washers - outside dia. G	43.900	43.916	0.110	0.137			Clearance on radius
	36	Labyrinth seal - inside dia. G	44.136	44.175					
	51	Turbine - inside dia. H	118.600	118.740	0.200	0.340			Clearance on radius
	36	Labyrinth seal - outside dia. H	118.060	118.200					
	51	Turbine disc Nozzle inner ring - clearance J				1.000	1.500		Clearance obtained by varying the total thickness of adjusting washers (50) For tapered turbines take blade tip clearance into account.
	75 62 65	Nozzle guide vanes gas intake casing or spacer - clearance K			0.100	0.150			To obtain this clearance file the inner face of the vane inner platform
	51	Turbine - outside dia. L	121.860	121.900	0.600	0.780			
	30	Rear bearing - inside dia. L	122.500	122.640					

Turbocharger unit serial No	INDEX No	Description of clearances and reference letters	NEW PART				WORN PART		REMARKS
			DIMENSIONS		CLEARANCES		Max. clearance	Reject dimension	
			MIN.	MAX.	MIN.	MAX.			
	51	Turbine blades - circumferential movement M				0.150			Movement checked at blade tip on leading edge side
	51	Turbine disc - balancing land N							Maximum chickness of material that can be removed : 3.5 mm
	51	Turbine with integral blades - P1 - P2 - P3							Rework for balance. Do not remove more material than land thickness - max. thickness of material removed : 1 mm - max. thickness of material removed : 2.5 mm
	84	Diffuseur cover Labyrinth seal lips - dia. R1 - dia. S1 - dia. T1 - dia U1	 234.800 220.700 206.600 192.600	 234.872 220.772 206.672 192.672					
		Clearance R S T U			0.400 0.350 0.300 0.300	0.472 0.422 0.372 0.372			Clearance on radius
	90	Impeller labyrinth seal lips - dia.R2 - dia.S2 - dia.T2 - dia.U2	 233.928 219.928 205.928 191.928	 234.000 220.000 206.000 192.000					

Turbocharger unit serial No	INDEX Nº	Description of clearances and reference letters	NEW PART			WORN PART		REMARKS
			DIMENSIONS		CLEARANCES	Max. clearance	Reject dimension	
			MIN.	MAX.	MIN. MAX.			
0001 and 1001	101 85	Compressor casing and diffuser (85) Diffuser cover - Nip "V"			0.100 0.300			Correct nip obtained by varying the total thickness of adjusting shims (108)
All HS 400 turbochargers	95	Inducer and bush assembly - inside dia. W	24.000	24.013				
0001-1001-2001- 3001-4001-5001- 6001-7001-17001- 20001-22001-23001- 27001-29001-37001- 49001-50001-52001- 53001-56001-57001- 61001-62001-64001-	73 51	Outer ring Turbine - clearance X		..	0.700 1.000			
10001-13001-14001- 18001-21001-24001- 33001-36001- 38001-39001-42001- 44001-45001-49001- 55001-59001-60001- 63001-	73 51	Outer ring Turbine - clearance X			0.800 1.100			
8001-12001-15001- 16001-19001-25001- 26001-28001-31001- 34001-35001-40001- 41001-43001-46001- 47001-54001-58001-	73 51	Outer ring Turbine - clearance X			1.100 1.400			
0001-1001	92 103	Compressor impeller Compressor casing - clearance Y			0.600 0.700			

Turbocharger unit serial No	INDEX No	Description of clearances and reference letters	NEW PART				WORN PART		REMARKS
			DIMENSIONS		CLEARANCES		Max. clearance	Reject dimension	
			MIN.	MAX.	MIN.	MAX.			
All turbochargers except 0001-1001	92 103	Compressor impeller Compressor casing - clearance Y			0.700	0.800			
10001-13001-14001- 18001-21001-24001- 33001-36001-38001- 39001-42001-44001- 45001-49001-55001- 59001-60001-63001-	62	Gas intake casing - inside dia. Z	253.000	253.081	0.056	0.218			
	73	Outer ring - outside dia. Z	252.863	252.944					
8001-12001-15001- 16001-19001-23001- 25001-26001-27001- 28001-31001-34001- 35001-40001-41001- 43001-46001-47001- 48001-52001-54001- 58001-61001-	62 or 65	Gas intake casing or Casing spacer - inside dia. Z	262.000	262.081	0.056	0.218			
	73	Outer ring - outside dia. Z	261.863	261.944					
0001-1001-2001-3001 4001-5001-6001-7001 17001-20001-22001- 29001-37001-50001- 53001-56001-57001- 62001-64001-	62	Gas intake casing - inside dia. Z	240.000	240.072	0.050	0.194			
	73	Outer ring - Outside dia. Z	239.878	239.950					
0001-2001-3001	73	Outer ring - dimension A1	9.730	9.820					
		- clearance A3 = (A1-A2) (A2-A1)			0.070*	0.17			
All turbochargers	75	Nozzle guide vane - dimension A2	9.650	9.800					* Interference
		- clearance A3 = (A1-A2) (A2-A1)			0.100*	0.140			
All turbochargers except 0001-2001-3001	73	Outer ring - dimension A1	9.700	9.790					

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TABLE OF MATERIALS

HS 400 TURBOCHARGER

70.1. TABLE OF MATERIALS

Ref. No	Materials and brands	Application	Suppliers
1	- Well seal or as an alternative - GEBOIL paste (see product No 23)	Sealing of - compressor casing joint faces	Well Worthy Ltd Lymington-Hants England
2 3	- Fel Pro C5A or as alternatives - Aero-Shell compound 8	- Bolts and studs	Fel-Pro Incorporated Skokie Illinois U.S.A.
4	- Molykote grade (G or Z or M77) or		Société Imprex 28, av. de l'Opéra 75 - PARIS 2ème
	- Never-seez		Transmondial 7 av. du Président Wilson 92 LEVALLOIS-PERRET FRANCE
5	- MOLYSLIP	Lubrication of : - rear bearing bolt - gas intake casing bolt - turbine and impeller nuts - turbine splines and shaft splines at turbine end	YACCO-COPASLIP 50 av. de la Grande Armée 75 PARIS 17ème FRANCE
6	- SKOLY C5A	Lubrication of : - splines other than those mentioned above in 5	Ets SKOLY 4 rue Denis Epitalon 42 St ETIENNE FRANCE
7	- Paintex P	- cleaning of compressor casing studs	S.P.C.A. 7, quai Marcel Boyer 94 IVRY FRANCE
8	- White spirit	- general cleaning	
9	- Loctite A or B	- bonding of : self-tapping threaded inserts for compressor casings	COMET 12, rue de Lorraine 92 LEVALLOIS-PERRET FRANCE
10	- engine oil (that used on the engine)	- lubrication at assembly of turbocharger	
11	- Rouge organol Penetrant J 138	- dye penetrant inspection	Colloïde Industriels Français 4 & 6 rue Raymond David 92 MALAKOFF France
12 13	- developer CIF for cracks or as an alternative - Ardrox 996 (in atomizer)		Framalite Dt Ardrox 2, rue Meissonnier PARIS 17ème

HS 400 TURBOCHARGER

Ref. No	Materials and brands	Application	Suppliers
14	Ardrox grade 185 E2 CAUTION : this product must not be used on aluminium parts or	cleaning of - cast iron parts - steel parts parts in contact with exhaust gases	see No 12
15	NETAL D 91 (method No 1) or	- exhaust casing - compressor casing (painted, with loosely adhering carbon deposits)	see No 7
16	NETAL (Method No 2) or	- ditto -	see No 7
17	ORTHONETOIL P	- gas intake casing - nozzle assy (rings, vanes) - turbine disc - turbine labyrinth seals (parts with firmly adhering carbon deposits formed at high temperatures)	see No 7
18	ARDROX grade 59/1	- protection of cast-iron and steel parts after cleaning	see No 12
19	ARDROX grades 607-6061-6025-or 6003-60S	- cleaning of aluminium parts	see No 12
20	Alodine 1200	- local protection of rectified areas on diffuser - protection of non-painted aluminium parts	Cie Française des Produits Industriels CFPI 177, quai du Dr Dervaux 92 ASNIERES FRANCE
21	Bonderite Retouche	- protection of parts with Parcolubrite finish	Sté Continentale PARKER 42, rue Chance Milly 92 CLICHY FRANCE
22	Liquid nitrogen	- Fitting of parts with interference fit	AIR LIQUIDE 75 quai d'Orsay 75 PARIS 7ème
23	Pâte GEBOIL	- to improve the sealing of bearing gaskets	Ets BARTHELEMY 64 rue Defrance 94 VINCENNES FRANCE
24	Kerosene	- testing of water and oil systems for leaks	

Ref. No	Materials and brands	Application	Suppliers
25	Teflon tape	- sealing of oil passage blanking plug (7) - fitting of gas outlet casing plug	Ets BERWING 181 rue Philippe Triaire 92 NANTERRE

NOTE : Protection of the compressor casing, diffuser and cover, compressor impeller and inducer by chromic anodizing is carried out in accordance with manufacturer's process procedures.
The protective treatment of these parts can be performed only in perfectly equipped workshops experienced in this kind of operation.

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MAINTENANCE TOOLS

80.1. MAINTENANCE TOOLS

80.1.1. Special tools

Hexagon spanner with 18 mm square drive	923/78
Hexagon spanner with 23 mm square drive	924/78
Bearing extractor	926/78
Turbine extractor	925/78
Turbine and compressor impeller withdrawing tool including:	97500/78
- special jaws for turbine	97502/78
- special jaws for impeller	97501/78
- jaw holding tool	97510/78
Spanner for turbine and impeller nuts	927/78
Shaft holding spanner	928/78
Bearing assembly tool including :	92000/78
- front bearing support block	92010/78
- rear bearing support block	92020/78
- mandrel for front and rear bearing	92030/78
Tool for fitting the anti-vibration wire	800143/14
Drill jig for fitting wire thread inserts (gas outlet casing)	95500/78

80.1.2. Common tool

Torque wrench - 0 to 0.2 m.daN	*
Torque wrench - 0 to 10 m.daN	*
Torque wrench 10 to 20 m.daN	*

80.1.3. Inspection tool

Speed pick-up (see plate 1)	
- for compressor casings with dimension L = 47 mm	53487
- for compressor casings with dimension L = 87 mm	53620
Frequencymeter possible voltages 220 V a.c. and 72 V d.c.)	
- fixed, panel-mounted type for test rig	249995
- portable type	249998
Plain and splined plug gauge	707301/14
Splined plug gauge	733301/14
Set of 0.01 mm feeler gauges	*
Slide callipers	*
Depth gauge with removable base 250x250 - ROCH 170A28C	*
Gauges to be made up of 3 pieces of piano wire of 1 mm, 1.2 and 1.5 mm dia., 120 mm long, bent through 90° at 20 mm from an end	*
Dial indicator	*
Dial indicator magnetic base	*

80.1.4. Tools for checking and adjusting the turbine nozzle throat area

"Intramess" area checking tool including	
- bore gauge, capacity 7 to 10 mm	844H
- dial indicator	803ST
Set of Johnson gauge blooks	*
- centralizing tool	700675/14

Throat area increasing tool :	
- for turbochargers with series 9 nozzle	947/78
- for turbochargers with series 0 or 8 nozzle	949/78
- for turbochargers with series 6 nozzle	950/78
Throat area reducing tool :	
- for turbochargers with series 9 nozzle	951/78
- for turbochargers with series 0 or 8 nozzle	953/78
- for turbochargers with series 6 nozzle	954/78

NOTE : this tool is also used to restore the vane trailing edge straightness

80.1.5. Cleaning equipment

Spray gun	*
Brushes	*

* These tools (commercial standard tools) are not supplied by the manufacturer and are mentioned only for information The only tools delivered by the manufacturer against a purchase order are those for which a part No is given. (See Illustrated Parts Catalogue of HS 400 Turbocharger)

80.2. Spares for maintenance

80.2.1. Maintenance kit

The maintenance kit (Ref.6115) is composed of small consumable parts enabling to carry out the re-assembly of two turbochargers.

80.2.2. Parts for repair

	Part No
- Threaded insert for oil inlet port	6968
- Threaded insert for rain water drain hole	6970
- Threaded insert for oil outlet, water inlet and outlet connection securing bolt holes	6971
- Threaded insert for securing bolt holes in : - mounting support - gas intake casing - gas exhaust casing	6969
- Oversize studs for compressor casing attachment	3433-99
- Oversize insert for air intake duct or manifold securing bolt hole	557214
- Threaded insert for rear bearing securing bolt hole	53613

90

MODIFICATIONS

90. MODIFICATIONS

90.1. Identification of modifications embodied on turbochargers

Some modifications embodied in the turbocharger require that a corresponding change letter (letter B through Z) be marked in one of the eighteen spaces on the nameplate or one of the twelve spaces on a separate plate as the case may be.

The change letters of embodied modifications are marked in their respective alphabetical order, leaving blank the spaces for change letters of modifications no yet embodied (e.g. optional modification)
The first space of the plate can be used for a cumulative change letter.

Example No 1 : Modifications embodied : B.D.E.F.H

Modifications not embodied : C.G.

B D E F H

Example No 2 : Modifications embodied : B.C.D.E.F.H

Modifications not embodied : G

F H

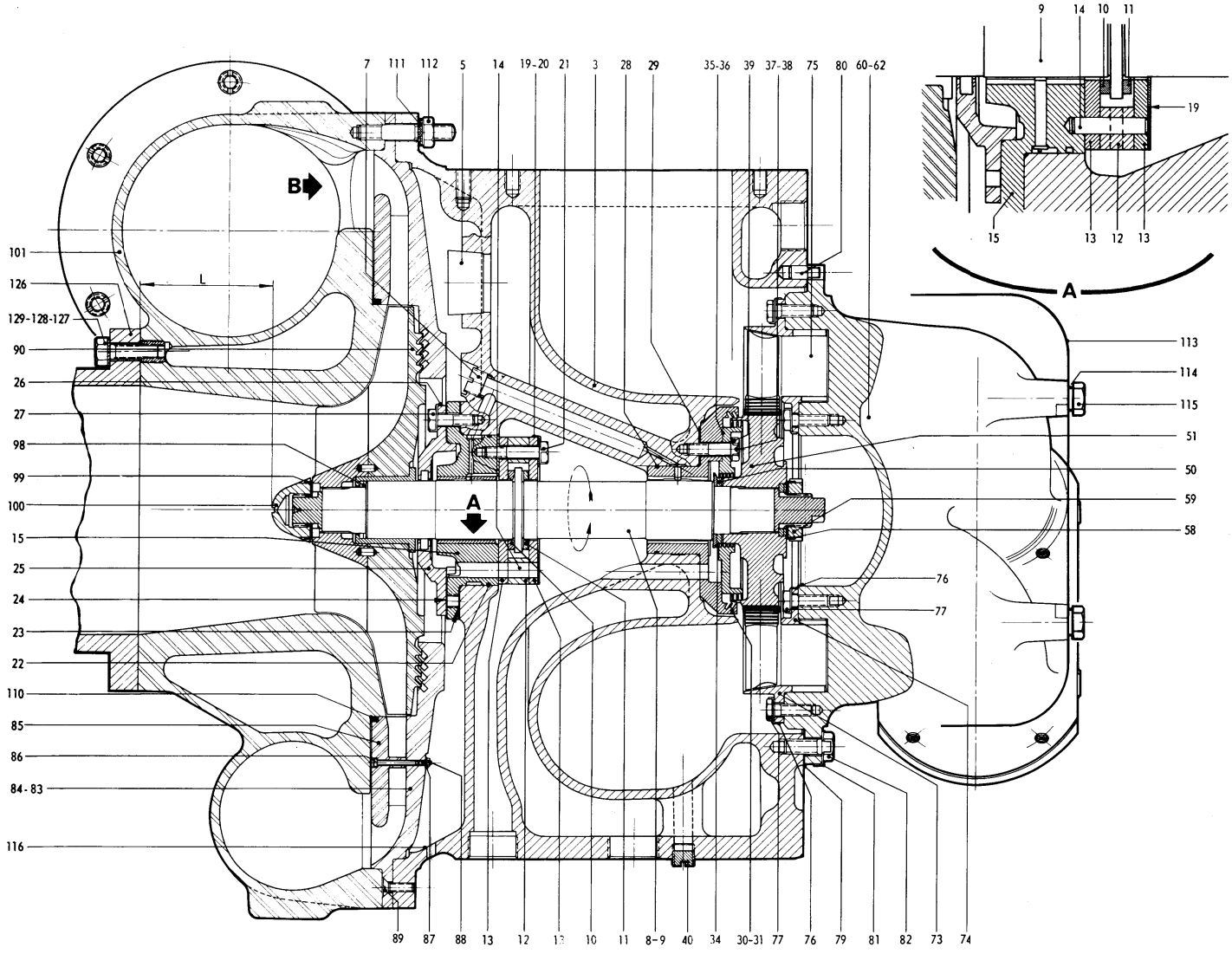
The letter F in the first space denotes that all previous modifications are embodied up to change letter F inclusive.

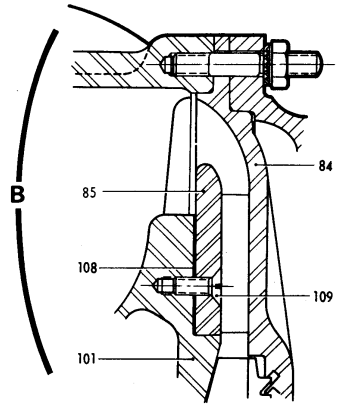
90.2. Table of modifications

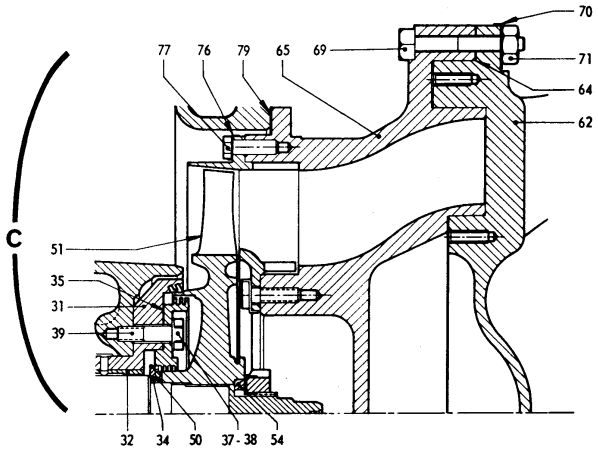
Embodiment data and accomplishment instructions for major modifications are supplied by the After-Sales Department of the Hispano-Suiza division in the form of HISPANO-SERVICE bulletins.

PL 1

COUPE DE L'ENSEMBLE
CROSS SECTION OF ASSEMBLY
LANGSSCHNITT
SECCION TRANSVERSAL

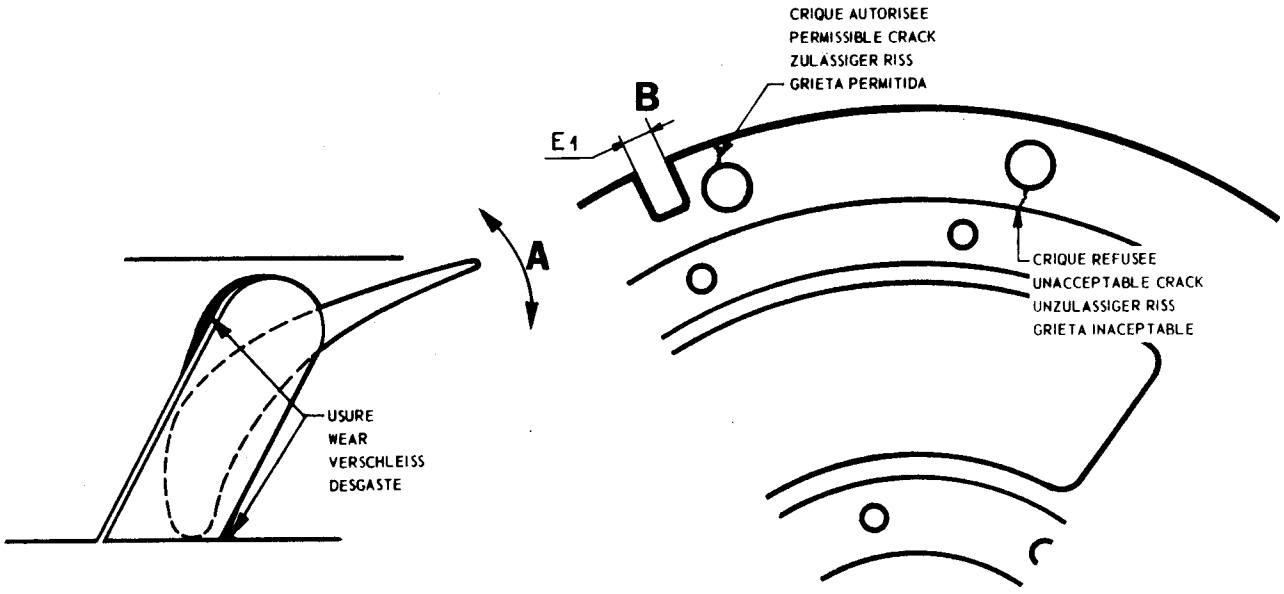






TURBOCOMPRESSEURS HS. 400

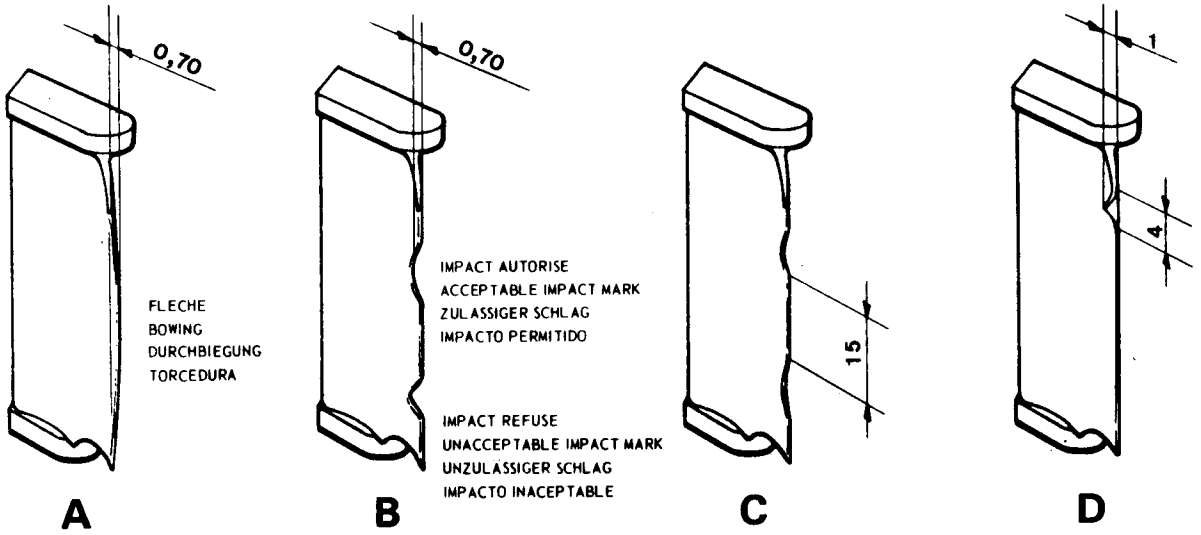
PL 2.3



USURE DES LOGEMENTS D'AUBES
WEAR OF NOZZLE GUIDE VANE LOCATING SLOTS
VERSCHLEISS DER LEITSCHAUFELNKERBEN
DESGASTE DE LAS RANURAS DE ALETAS

USURE ET CRIQUES SUR L'ENSEMBLE DISTRIBUTEUR
WEAR AND CRACK ON TURBINE NOZZLE ASSEMBLY
VERSCHLEISS UND RISSE AN LEITAPPARATGESAMTHEIT
DESGASTE Y GRIETAS EN EL CONJUNTO DE DISTRIBUCION

PL 2

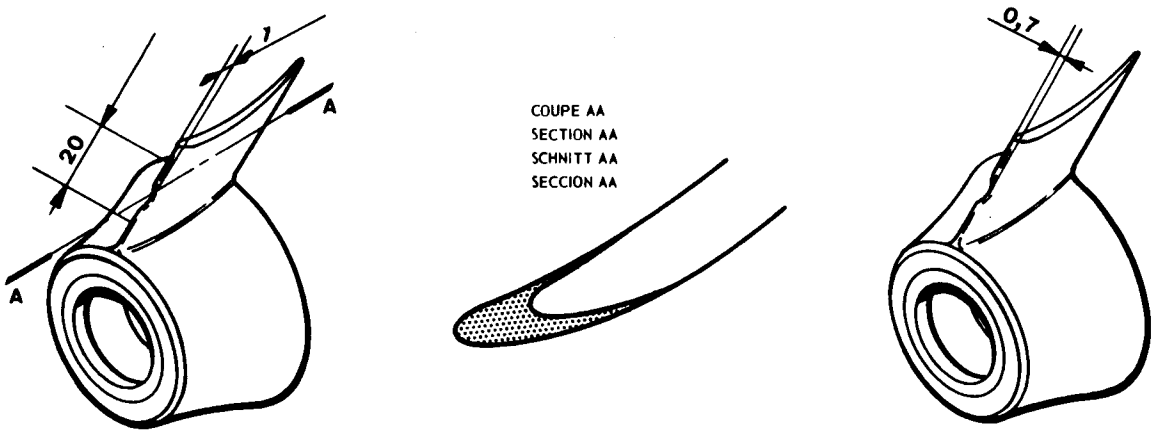


DEFORMATIONS ET IMPACTS SUR LES AUBES DIRECTRICES
DISTORTION AND IMPACTS MARKS ON NOZZLE GUIDE VANES
VERZÜGE UND SCHLÄGE AUF LEITSCHAUFELN
DEFORMACIONES E IMPACTOS EN LAS PALETAS DIRECTRICES

PL 3

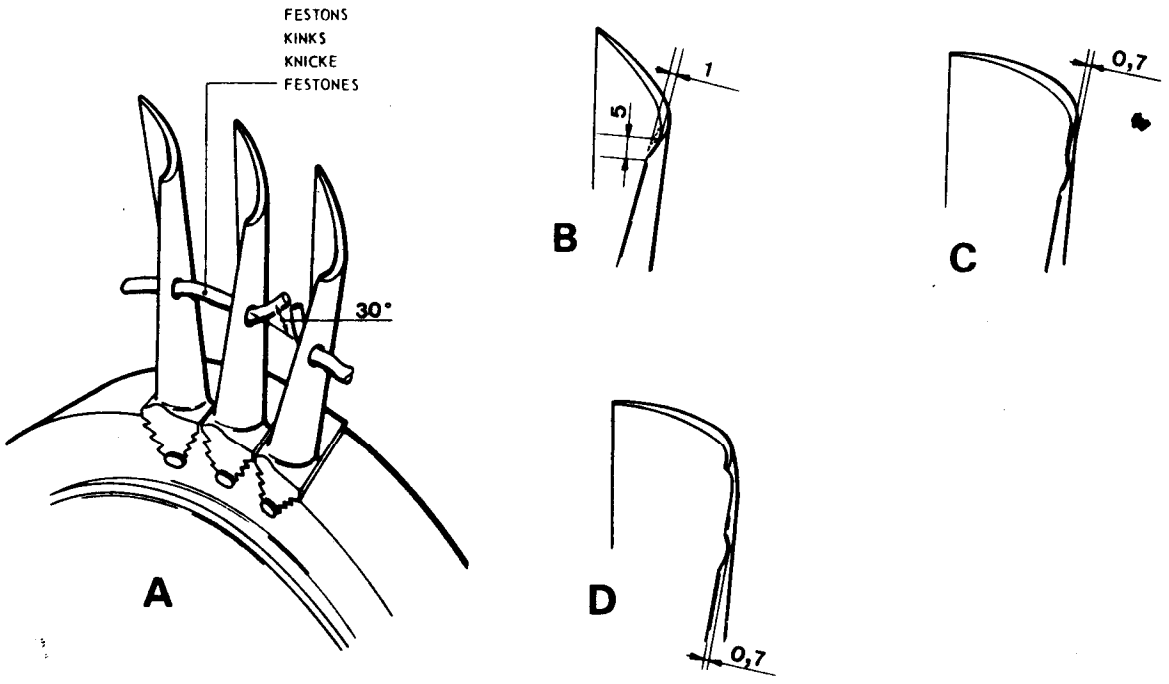
TURBOCOMPRESSEURS HS. 400

PL 4.5



DEFORMATIONS ET IMPACTS SUR ROUE D'ENTREE
DISTORTION AND CRACKS ON ROTATING GUIDE VANES
VERZÜGE UND SCHLÄGE AUF VORSATZLÄUFER
DEFORMACIONES E IMPACTOS EN EL ANILLO PORTAPALETAS

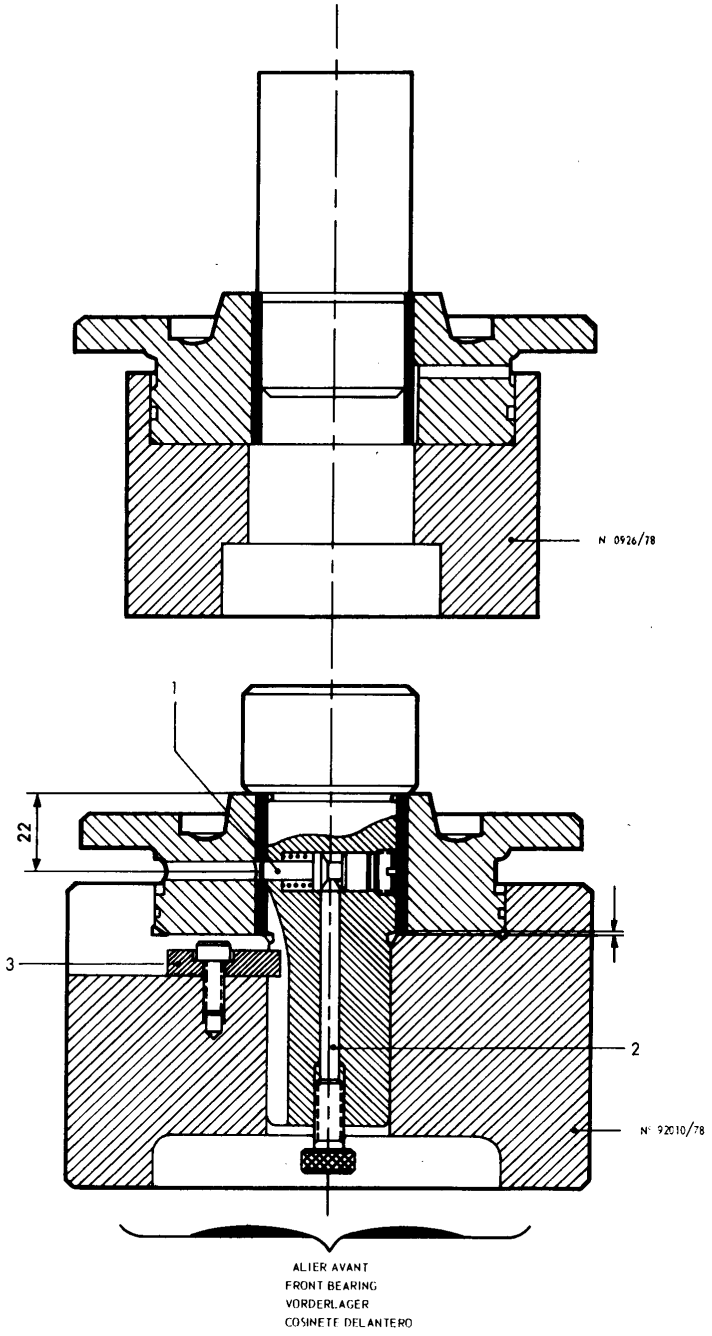
PL 4



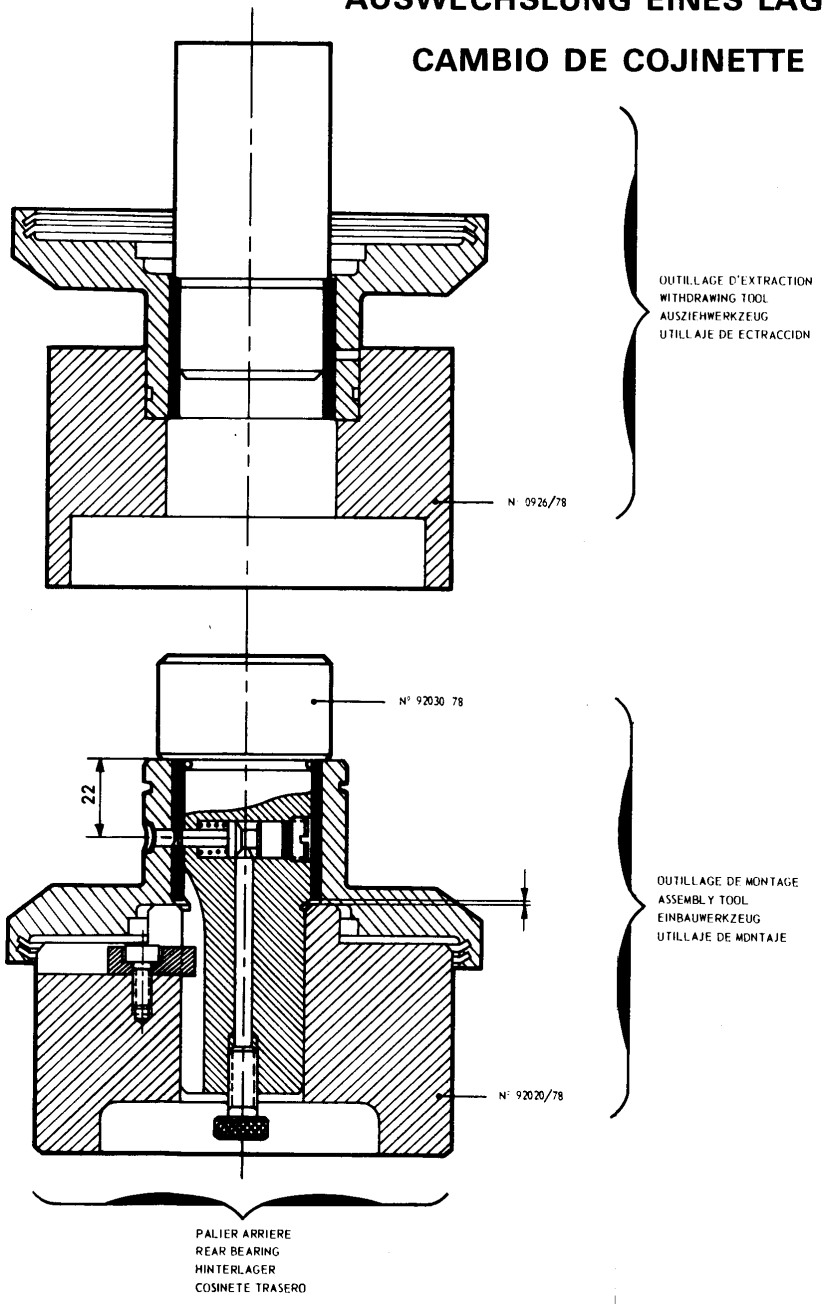
DEFORMATIONS ET CRIQUES DES AILETTES DE TURBINE
DISTORTION AND CRACKS ON TURBINE BLADES
VERZÜGE UND SCHLÄGE AUF TURBINENSCHAUFELN
DEFORMACIONES Y GRIETAS EN LAS PALETAS DE LA TURBINA

PI 5

ECHANGE D'UN COUSSINET
REPLACEMENT OF A BEARING
AUSWECHSLUNG EINES LAGERS
CAMBIO DE COJINETTE



ALIER AVANT
FRONT BEARING
VORDERLAGER
COSINETE DELANTERO



PALIER ARRIERE
REAR BEARING
HINTERLAGER
COSINETE TRASERO

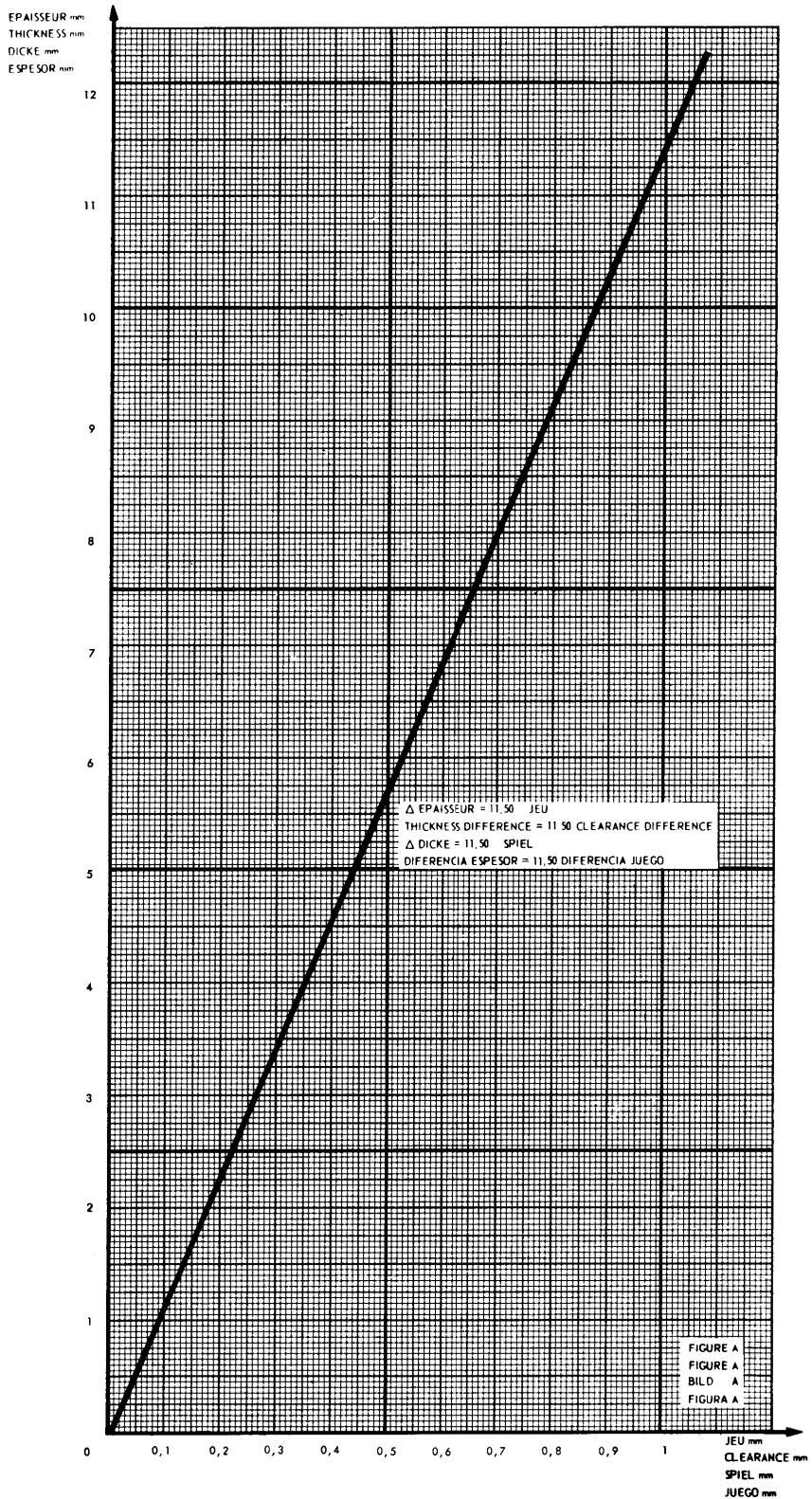
PL 7

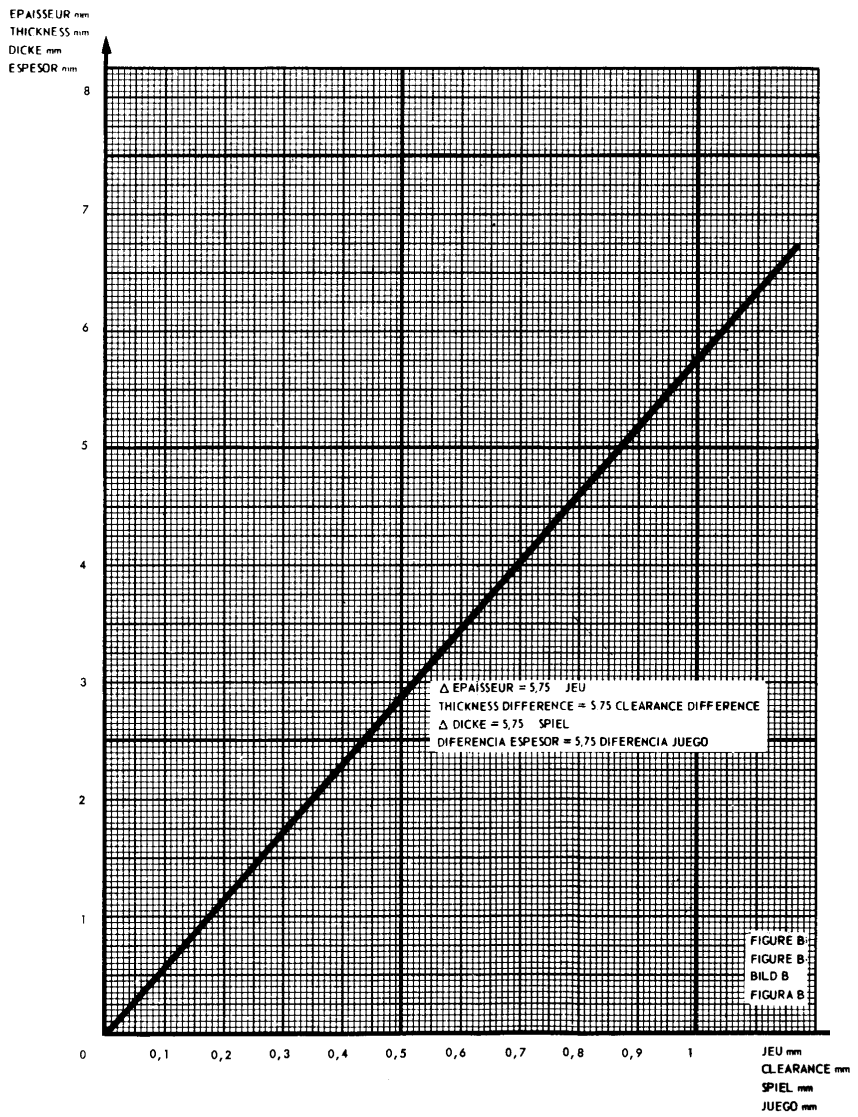
GRAPHIQUES DE REGLAGE TURBINE CONIQUE

TAPER TURBINE CLEARANCE ADJUSTMENT DIAGRAMS

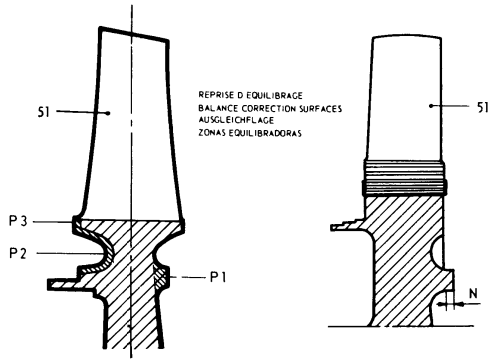
EINSTELLTABELLE KEGELFÖRMIGE TURBINE

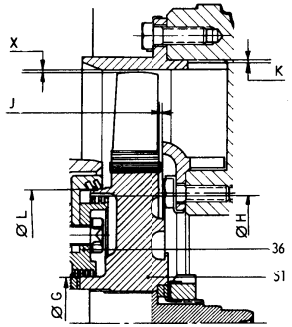
GRAFICO DE REGULACION TURBINA CONICA

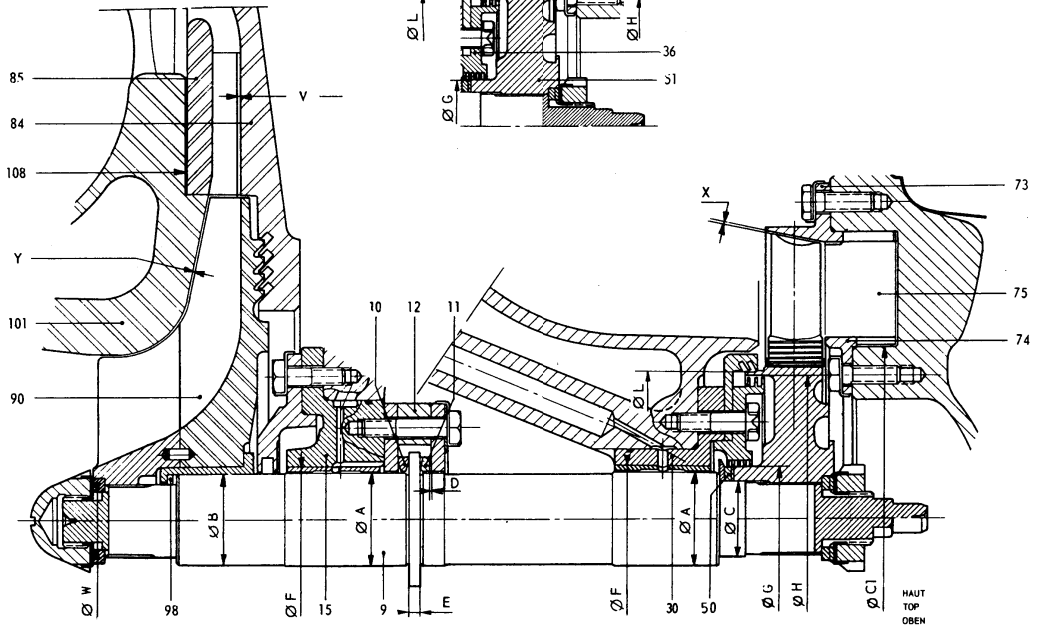


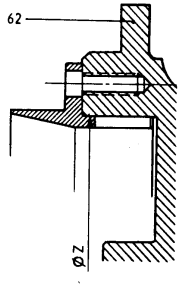


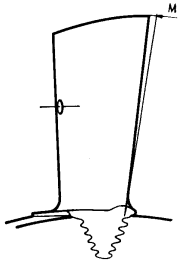
JEUX ET TOLERANCES
FITS AND CLEARANCES
SPIELRÄUME UND TOLERANZEN
JUEGOS Y TOLERANCIAS

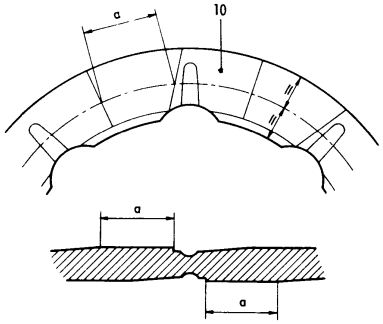


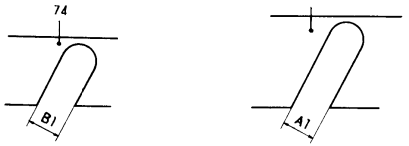


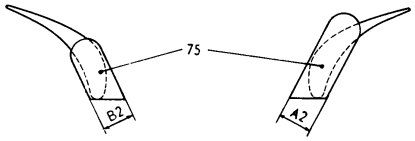


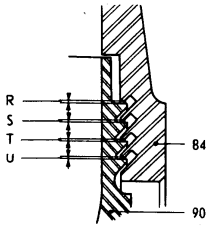


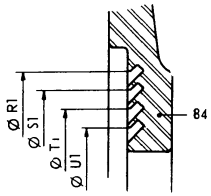


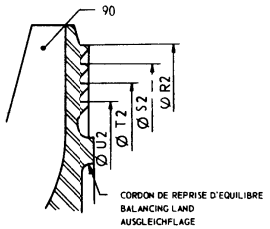


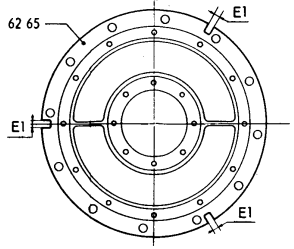


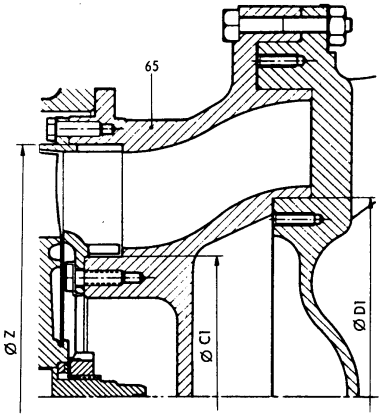












REGLAGE DE LA SECTION DE PASSAGE DU DISTRIBUTEUR

ADJUSTMENT OF TURBINE NOZZLE THROAT AREA

EINSTELLUNG VOM LEITAPPARATDURCHGANGSQUERSCHNITT

REGULACION DE LA SECCION DE PASO DEL DISTRIBUITOR

