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Lubricating and Control Oils for Gas and Steam Turbines

Specification and supervision

Revision History

Revision	Content of Change	Total No. of document pages:
N	97-10-21, Extension of content, re-structuring of the text	-
P	98-02-11, Oil designations from Castrol have been changed	-
Q	99-06-16, Additional requirements and oil brands	-
R	00-05-17, Cleanliness class ISO 4406 changed to new standard, several oil suppliers added	-
S	02-10-01, Name changed to "ALSTOM", Section 2.1 deleted (exclusion of zinc), properties adapted to ALSTOM Group, supervision of impurities every month. Checklist included. Oil suppliers added.	-
T	04-01-10, Oil suppliers added, remark regarding Finspong deleted, table in Fig. 1, changed	20
U	05-07-20 Oil suppliers added	20



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1 GENERAL

This specification lays down the requirements, test methods and terms of delivery for lubricating (lube) and control oils, which ALSTOM uses in steam and gas turbines.

2 SCOPE OF APPLICATION

The mineral oils in accordance with this specification are refined mineral oils with additives which increase the resistance to ageing and improve the protection against corrosion. Small quantities of other additives may also be added to achieve the required properties.

The mineral oils in accordance with this specification can be used in the lube and control oil systems of turbomachinery.



Note

It is usually not permitted to use mineral oil as control oil in hydraulic high pressure systems with a pressure > 120 bar!

2.1 Viscosity classes

Mineral oils of viscosity classes ISO VG 32 and 46 are usually used for steam or gas turbines.

ALSTOM normally employs viscosity class ISO VG 46 if the bearing oil inlet temperature is between 40 °C and 50 °C (104 °F and 122 °F).

Mineral oils of viscosity class ISO VG 32 can be used without problems up to a bearing oil inlet temperature of 45 °C (113 °F). These mineral oils are less suitable for turbosets with higher bearing oil inlet temperatures.

The use of mineral oils of viscosity class ISO VG 68 is possible with very high bearing oil inlet temperatures.

The ALSTOM Engineering Department responsible must principally be consulted for approving the viscosity class.

2.2 Terms of delivery

Depending on the agreement made between supplier and customer, the oil is supplied in tank cars or in clean, solid and dry barrels. The following minimum information must be provided in a legible and durable manner on each barrel:

- Designation of type and viscosity class
- Identification of product and supplier
- Charge or delivery number

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Note

When placing the order, a test certificate must be requested from the supplier for the supplied mineral oil.

The delivery must not be accepted if this condition is not fulfilled.

2.3 Notes on acceptance and first filling of the lube oil tank

The check of and procedure for acceptance on delivery and first filling of the lube oil tank are laid down in the checklist to be completed.

A copy of this checklist must always be sent to the ALSTOM Project Manager.

2.4 References

ISO 6743 part 5	Lubricants, industrial oils and related products Class L-Classification-Part 5 Family T (Turbines)
ISO 3448	Industrial liquid lubricants-ISO viscosity classification
ISO 4406	Hydraulic Fluid Power-Fluids - Method for coding level of contamination by solid particles
ISO 8068	Petroleum products and lubricants - Petroleum lubricating oils for turbines, categories ISO-L-TSA and ISO-L-TGA-Specifications
DIN 51519	ISO-Viscosity classification for liquid industrial lubricants

2.5 Properties

When checking an approx. 10 cm thick oil film in transilluminating light, the oil shall be bright and clear and free of visible foreign matter. The additives must not have negative effects on the materials of the oil system.

The table in Fig. 1 lists the limit values for the most important properties of the mineral oils and the approved test methods.

The viscosity characteristic in Fig. 2 shows the viscosity/temperature correlation.

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Requirements ¹⁾	ISO –viscosity class			Test method as per ⁹⁾	
	ISOVG32	ISOVG46	ISOVG68	ISO	ASTM
Viscosity at 40°C mm ² / s ²⁾	32 ± 10%	46 ± 10%	68 ± 10%	3104	D445
Viscosity index ³⁾	> 90			2909	D2270
Density at 15 °C	≤ 880 kg/m ³		≤ 900 kg/m ³	3675	D 941 D 1298
Flash point c.o.c.	≥ 200°C		≥ 205°C	2592	D 92
Pour point ⁴⁾	≤ - 9 °C		≤ - 6 °C	3016	D 97
Zinc content	≤ 5 ppm			Optional	
Acid number	Without EP add. ≤ 0.2 mg KOH / g			6618	D 664 D974
	With EP additive ≤ 0.3 mg KOH / g				
Air release at 50 °C	≤ 4 min		≤ 7 min	9120	D 3427
Foaming characteristic at 24 / 93.5 / 24 °C	At the beginning < 300/50/300 mL			6247	D 892
	After 5 minutes 0/0/0 mL				
Demulsibility after steam treatment ⁵⁾	< 300 sec. DIN 51589 Part 1				
Water separability 40 - 37 – 3	<30 min			6614	D 1401
Purity	Class --/18/15 as per ISO 4406 Class 9 as per NAS 1638 Class 5 as per SAE 749			4406	
Water content	< 200 ppm			12937	D 1533/ D1744
Oxidation stability TOST ⁶⁾	Increase in acid number after 2000h <1mg KOH/g			4263-1	D 943
Oxidation stability RPVOT ⁷⁾	> 300 min				D 2272
Copper corrosion at 100°C/ 3 hours	Max. stage 2			2160	D 130
Rust preventing characteristic (sea water)	Pass B			7160	D 665
Load carrying capacity FZG normal test A/8.3/90 ⁸⁾	Fail stage 8 only for turbines with gear DIN 51354-2			14635-1	D 5182
Filterability	Level I: at least 93%, Level II: at least 85%			13357-2	

Fig. 1 Specification table

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Notes on the table, Fig. 1

- 1) For turbine types that are presently available. If turbines are operated with oils that do not comply with this specification but do not cause problems, the oil filling can be left.
- 2) ALSTOM normally uses viscosity ISO VG 46. The viscosity must however be determined for each plant separately, depending on the oil temperature to be expected.
- 3) The viscosity index (VI) is a measure of the viscosity/temperature correlation. The requirement for the index is fulfilled if all viscosity values measured at temperatures between 20 °C and 100 °C (68 °F and 212 °F) or determined by extrapolation are within the range valid for this viscosity class. See the viscosity characteristic in the graph, Fig 2. Viscosity index improvers are not permitted because long-chain paraffins can cause clogging of the filter.
- 4) The pour point must be at least 10 °C below the lowest ambient temperature in winter, or a heater must be provided. An oil with a lower pour point, which is possibly not mentioned in the list of approved oils, can be used for special applications.
- 5) There is no sufficiently reliable correlation between demulsibility according to DIN 51589 and water separability according to ISO 6614 or ASTM D 1401. It depends on the national regulations of the country where the oil is used which of the two criteria must be fulfilled.
- 6) If required, a provisional ageing test can be made (Total Oxidation Products as per ISO 7624; IP280). Requirements: Increase in acid number: max. 1.8mgKOH/g. Sludge content < 0.4%. It is possible that the product does not pass the quick test but the subsequent 2'000h TOST test.
- 7) The limit value for new oil is not defined. The measurement is important as a reference value.
- 8) For turbines with gear an FZG fail stage of at least 8 is required (mineral oils with EP additives). The gear manufacturer may require other FZG fail stages for individual plants.
- 9) Equivalent test methods, for example DIN, NF, IP and BS methods can also be used.

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Comparison

Viscosity characteristics

Diagram 1

Conversion table

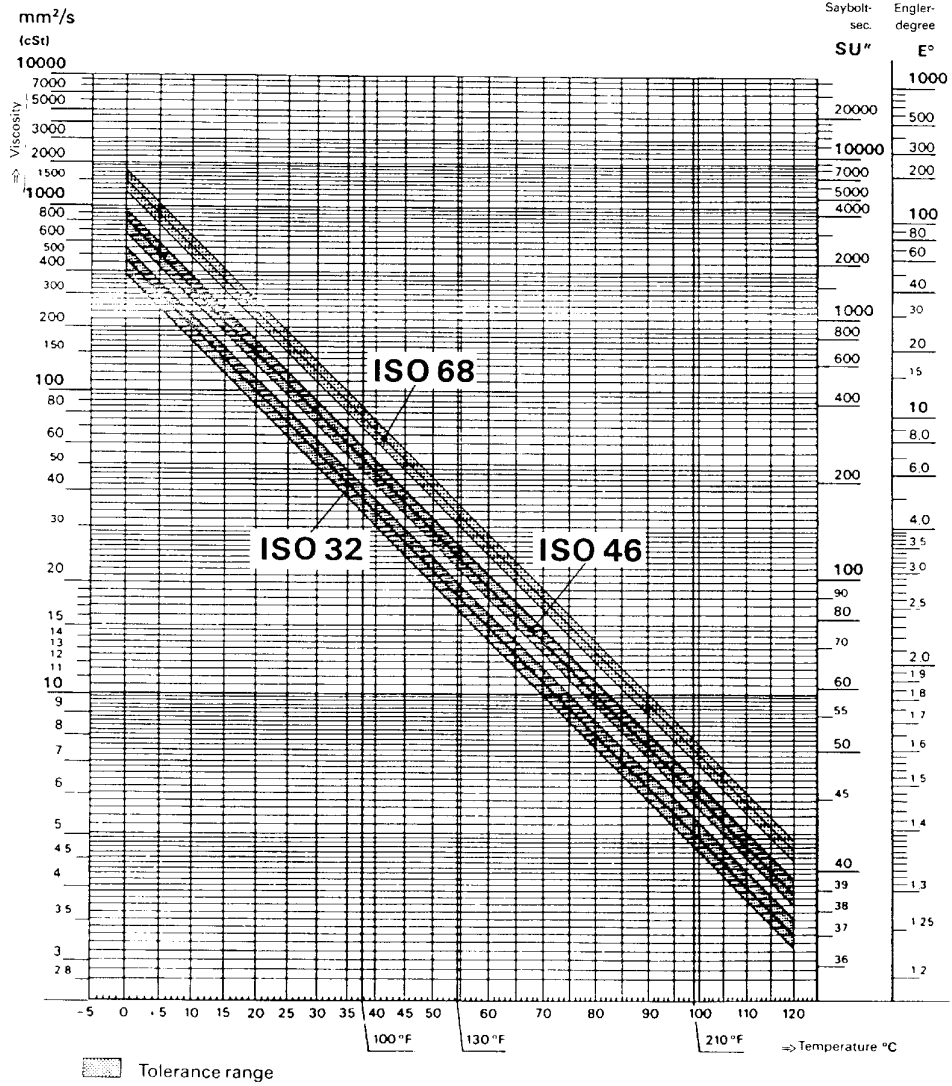


Fig. 2 Viscosity characteristics

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3 SUPERVISION

Periodic supervision of the lube oil condition permits assessment of the proper functioning of the system and early action in the case of malfunctioning.

Fig. 3 specifies the recommended periodic checks, standard values and corrective actions.

Test	Method	Frequency	Spec. value	Limit value	Action
Appearance, see chapter 3.2	Visual inspection	Once a month	Clear, light-yellow or coloured liquid	Cloudiness, dark discolouration	Analyse in laboratory
Water content in oil sample	Visual inspection		Clear liquid	Cloudiness (no free water)	Drain (centrifuge)
Solid impurities	SAE 749 D ISO 4406 NAS 1638		Class 4 Class 16/13 Class 7	Class 5 ¹⁾ Class --/17/14 ¹⁾ Class 8 ¹⁾	Filter. Replace filter
Filterability	ISO 13357-2	Once a year	Level I 93% Level II 85 %	Level I 80 % Level II 20 %	New filling
Water content according to Karl Fischer	ASTM D 4928 ISO 12937		100 mg/kg	500 mg/kg	Drain
Acid number	ASTM D664/ D974 DIN 51558 ISO 6618		According to original condition analysis	Max. 0.2 mg KOH/g above orig. value	Check RPVOT Contact oil supplier
Viscosity	ASTM D 445 DIN 51550/62 ISO 3104		According to ISO VG-class	Exceeding ISO VG	E.g. check refill oil. Find out reason
Air release at 50°C	DIN 51381 ASTM D 3427		4 min. ISO VG32/46 7 min. ISO VG68	8 min. ISO VG32/46 10 min. ISO VG68	Contact oil supplier
Water separability	ASTM D 1401 DIN 51599 ISO 6614		Max. 30 min.	Max. 30 Min.	Find out reason. Observe carefully. New filling in the case of poor oxidation stability
Demulsibility after steam treatment	DIN 51589		Max. 300 seconds	Max. 360 seconds	
Copper content (solved in oil)	Optional		< 10 ppm	Exceeding 15 - 25 ppm	Observe carefully
				> 30 ppm	In worst case: new filling
Oxidation stability RPVOT	ASTM D 2272		> 25% of new oil	> 100 min.	Contact oil supplier. Possibly new filling

¹⁾ For control oil class 4, ISO 4406 --/16/13, NAS 7

Fig. 3 Supervision

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3.1 Sampling

Take the oil samples for the monthly check of appearance and water content from the lower third of the oil tank.



Note

Take the oil sample from the pressure line downstream of the filter for the quantitative determination of impurities or for the annual check of the overall condition !

The oil system must have been in operation for at least 12 hours before taking the sample!

Prior to the actual sampling (approx. 1 litre) discharge approx. 3 to 4 litres of oil (2 to 3 litres for all tests according to Fig. 3) for flushing the valves. Rinse the clean sample bottle three times with oil.

The valve must not be closed between flushing and sampling. After taking the sample, close off tightly the sample bottle. If the test is not carried out in the plant's own laboratory, the bottle must bear the following information:

- Plant name
- Oil brand
- Point of sampling
- Date and operating hours of oil filling
- Quantity refilled since last oil analysis
- Total refill quantity since last oil filling

3.2 Explanatory notes on the tables

Appearance

When checking an approx. 10 cm thick oil film in transilluminating light, the oil shall be clear and free of visible foreign matter after settling down for 10 minutes.

Solid impurities

The solid impurities are classified in the following purity classes in accordance with their number and size per volume unit.

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ISO 4406 (excerpt from ISO standard)				
Class	Number of particles per 100 millilitre			
	> 6 µm		> 14 µm	
	more than	up to and incl.	more than	up to and incl.
--/20/17	500'000	1'000'000	64'000	130'000
--/19/16	250'000	500'000	32'000	64'000
--/18/15	130'000	250'000	16'000	32'000
--/17/14	64'000	130'000	8'000	16'000
--/16/13	32'000	64'000	4'000	8'000
--/15/12	16'000	32'000	12'000	4'000
--/14/11	8'000	16'000	1'000	2'000
--/13/10	4'000	8'000	500	1'000

Fig. 4 Purity classes as per ISO 4406

NAS 1638					
Class	Number of particles per 100 millilitre				
	5-15 µm	15-25 µm	25-50 µm	50-100 µm	> 100 µm
4	4'000	712	126	22	4
5	8'000	1'425	253	45	8
6	16'000	2'850	506	90	16
7	32'000	5'700	1'012	180	32
8	64'000	11'400	2'025	360	64
9	128'000	22'800	4'050	720	128
10	256'000	45'600	8'100	1'440	256
11	512'000	91'200	16'200	2'880	512

Fig. 5 Purity classes as per NAS 1638

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SAE 749		
Particle size µm	Purity class Number of particles per 100 millilitre	
	Class 4	Class 5
5 - 10	32'000	87'000
10 - 25	10'700	21'000
25 - 50	1'510	3'310
50 - 100	225	430
> 100	21	41

Fig. 6 Purity classes as per SAE 749



Note

Solid particles larger than 150 microns are not permitted!
If the lube oil is also used as control oil, it must have a purity of SAE class 4, ISO class --/16/13 or NAS 1638 class 7!

4 REFILLING THE OIL TANK

The lube oil tank shall principally be refilled with oil of the same brand and viscosity class.

Refill the clean lube oil system always via a filter having a mesh size of 10 µm in order to filter out impurities.



Note

Mixing of different oils may cause accelerated ageing and precipitation of additives!

Mixing of oils is only permitted after consulting the turbine and oil suppliers.

The oil supplier must also be consulted if other measures are required, such as re-inhibiting the oil. Such action is, however, only useful if previously test-ed successfully in the laboratory.



Note

It is recommended to record all refillings in order to permit changes in the oil to be correctly assessed.

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5 SELECTION OF THE OIL SUPPLIER

Principally only mineral oils are permitted that meet the requirements of the specification table in Fig. 1.

5.1 Tested lube and control oils

The lube and control oils, tested and approved by ALSTOM on the basis of the specification table in Fig. 1, are mentioned in Fig. 7.



Note

Without being asked, the oil supplier has to confirm in writing every 5 years that the oils mentioned in the list still have the same composition and properties as stated in the table in chapter 2.5.

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Brand name	Designation	Date of last oil test	With EP additive FZG extra req.	
			no	yes
ADDINOL	Turbinenöl TL 32		X	
	Turbinenöl TL 46	May 1994	X	
ADNOC	Turbine Oil 32	November 2004	X	
	Turbine Oil 46	November 2004	X	
AGIP	OTE 46	May 1992	X	
	OTE 32 EP	January 2004		X
	OTE 46 EP	January 2004		X
Behran Oil Co.	Turbine Oil 46	Juli 2003	X	
BP	Turbinol 32		X	
	Turbinol 46	January 1992	X	
	Energol TH-HT 32		X	
	Energol TH-HT 46		X	
	Turbinol X 32	October 1999	X	
	Turbinol X 46	October 1999	X	
	Turbinol X-EP 32	October 1999		X
	Turbinol X-EP 46	October 1999		X
BP Lubricants North America	BP Turbinol Select 32	November 2003	X	
Caltex	Regal R & O 32		X	
	Regal R & O 46	June 1989	X	
	Regal EP 32			X
	Regal EP 46			X
	Regal Premium EP 32	August 1999		X
	Regal Premium EP 46	August 1999		X
Castrol Heavy Duty Lubricants	Perfecto T32		X	
	Perfecto T46		X	
	Perfecto HPT46	May 1995	X	
	Perfecto AWT 46	March 2000		X
	Perfecto XPT 32	October 1999	X	
	Perfecto XPT 46	October 1999	X	
	Perfecto XPG 32	October 1999		X
	Perfecto XPG 46	October 1999		X
	Turbine Oil 32	September 2002	X	
Cepsa	ODIEL EP46	1989		X
	ODIEL EP 32			X
	Turbinas EP 46	December 2000		X
Chevron by a Chevron company	GST Oil ISO 32	January 1990	X	
	GST Oil ISO 46	March 2000	X	
	Chevron GST 2300 ISO 32	February 2005		X
	Chevron GST 2300 ISO 46	February 2005		X
Conoco	Hydroclear Multipurpose R&O Oil 46	April 2000		X
	Hydroclear Diamond Class ® AW 32	November 2003		X
	Hydroclear Diamond Class ® AW 46	November 2003		X

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Brand name	Designation	Date of last oil test	With EP additive FZG extra req.	
			no	yes
Fuchs EUROPE Schmierstoffe GMBH	Renolin Eterna 32			X
	Renolin Eterna 46	June 1989		X
Elf France	Turbelf SA32		X	
	Turbelf SA46		X	
Engen Petroleum Limited	Engen Superturb 46	June 2004	X	
Enoc	Vortex 32			X
	Vortex 46			X
Exxon/Esso by Exxon Mobil	Teresstic T 32	February 2002	X	
	Teresstic T 46	February 2002	X	
	Teresstic GTC 32	November 2002	X	
Great Wall Lubricant Company, Sinopec	Great Wall Turbine Oil 32	December 2004	X	
Imperial oil	Oil 1893 (ISO VG 32)	September 2002	X	
	Oil 2062 (ISO VG 46)	September 2002	X	
Mobil by ExxonMobil	DTE797 (ISO VG32)		X	
	DTE798 (ISO VG46)		X	
	DTE 832	July 2005		X
	DTE 846	July 2005		X
	Mobil SHC 824 ¹⁾	July 2003	X	
	Mobil SHC 825 ¹⁾	July 2003	X	
Mol Hungarian Oil & Gas Co.	Turbokomol 32 K	September 1997	X	
	Turbokomol 46 K	July 2005	X	
Petrobras	Lubrax Industrial Turbina EP 46	May 2002		X
Petrogal	Galp Turbinoil 32	August 1999		X
	Galp Turbinoil 46	August 1999		X
Petrol Ofisi	PO Turbine Oil TX 32	July 2005	X	
Schmierstoff-raffinerie Salzbergen GmbH	Wintershall Wiolan DW32		X	
	Wintershall Wiolan DW46		X	
Shell	Turbo Oil T32	August 2001	X	
	Turbo Oil T46	August 2001	X	
	Turbo CC 32	September 1999		X
	Turbo CC 46	September 1999		X
Texaco	Regal EP 32			X
	Regal EP 46	July 1995		X
	Regal Premium EP32	August 1999		X
	Regal Premium EP46	August 1999		X
Total	Preslia 32			X
	Preslia 46	March 1987		X

¹⁾ Basis: Synthetic hydrocarbon

Fig. 7 ALSTOM-tested lube and control oils as of July 2005

Most of the oils are also available as ISO VG 68.

5.2 Untested lube and control oils

The following possibilities exist if a plant operator wants to use a mineral oil that has not been tested by ALSTOM:

- The oil is tested in ALSTOM's laboratory in accordance with the specification table in Fig. 1 and at the expense of the oil supplier. It is approved if all requirements are met. The test requires approximately 4 months because of the ageing test (2'000 hours).
- If ALSTOM agrees, some tests can be carried out in certified laboratories.

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6 CHECKLIST

Notes on the acceptance of and procedure for the delivery of oil or hydraulic medium to the plant and for the first filling of the lube oil or hydraulic tank

Plant:.....		ALSTOM order No.:.....	
Customer/plant operator:			
Medium supplier:		Medium/type:	Viscosity: ISO VG
Delivery:		<input type="checkbox"/> Tank cars	<input type="checkbox"/> Barrels
Carrier:.....		other	
Date of delivery:.....		Supplied quantity:.....	
Does the supplied type agree with the ordered medium type?			
Test certificate of the supplier must be available: Available <input type="checkbox"/> yes <input type="checkbox"/> no (chapter 2.3 of specification)			Date:
Sampling on delivery: Before unloading or filling the lube oil/hydraulic tank, at least 3 samples of approx. 2 litres each must be taken from the supplied charge and forwarded to the chemical engineer of the customer (to ensure subsequent traceability). The samples must at least bear the following information in a legible and durable manner: <ul style="list-style-type: none"> • Identification of supplier and product (type, viscosity class) • Carrier, date of delivery, charge or delivery No. • Name and order No. of turboset 			
Medium will be used for: <input type="checkbox"/> Brg. oil lubrication with hydraulic system <input type="checkbox"/> Only brg. oil lubrication <input type="checkbox"/> Hydraulic system			
Filling the tank: When filling the tank for the first time, the medium must be passed through a filter unit (e.g. oil centri-fuge, filter re-pumping unit or similar unit). Minimum requirement: 25 µm filter cloth over filling opening. See also flushing instructions for the plant in question.			
Date of filling:		Filled-in quantity:	
Filter unit used:		Filter mesh:	
Date:.....		Initialled by ALSTOM representative: (Commissioning/Erection Project Man.)	
Checklist and test certificate of oil supplier (see above) forwarded to ALSTOM PM on:.....			

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