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Hydraulic fluid power — Method for evaluating water separation performance of dehydrators

Déshydrateurs fluides hydrauliques — Méthode d'évaluation des performances de séparation de l'eau

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 6, *Contamination control*.

Introduction

In hydraulic fluid power systems, one of the functions of the hydraulic fluid is to separate and lubricate the moving parts of components. The presence of water contamination in the lubricant causes corrosion, loss of lubrication properties, increased oxidation rates, worse filterability, reduced filter service life and produces wear, resulting in loss of efficiency, reduced component and hydraulic fluid life and subsequent unreliability.

Hydraulic fluid dehydration equipment is used to remove the water contamination from these hydraulic fluids to well below the hydraulic fluid's water saturation level. Hydraulic fluid dehydrators are usually self-contained systems, designed to perform the function of water removal from a body of hydraulic fluid using different types of principles and methodologies. This document provides a procedure by which to evaluate the water removal performance of the various types of hydraulic fluid dehydrators in a well-defined, repeatable manner. This enables the purchaser of the hydraulic fluid dehydrator to compare the available products evaluated using the same test procedure.

Hydraulic fluid power — Method for evaluating water separation performance of dehydrators

1 Scope

This document specifies:

— test equipment, test circuit and a procedure for the evaluation of the water separation capabilities of a dehydrator;

— a procedure for preparing test fluid;

— a procedure for obtaining and analysing the test fluid samples.

This document applies only to those dehydration units that can dry a hydraulic fluid to less than 20 % of the hydraulic fluid's water saturation level at the test temperature.

This document provides a test procedure that yields reproducible results for dehydrator water removal performance so that the performance of candidate units is compared on the same basis using the same test fluid.

This procedure can be used to test the dehydrator's capabilities on different types of hydraulic fluids at different conditions. Parts of the procedure might need to be changed to suit the hydraulic fluid's characteristics. For example, the testing of hydraulic fluids with high water solubility (many synthetic and fire-resistant fluids) needs higher concentrations of water at the start of the test; the testing of hydraulic fluids with zinc-based additives needs modifications to the Karl Fischer analysis procedure. However, comparison of performance can be made under the conditions defined in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 760, *Determination of water — Karl Fischer method (General method)*

ISO 1219-1, *Fluid power systems and components — Graphical symbols and circuit diagrams — Part 1: Graphical symbols for conventional use and data-processing applications*

ISO 4021, *Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system*

ISO 5598, *Fluid power systems and components — Vocabulary*

ISO 6743-5, *Lubricants, industrial oils and related products (class L) — Classification — Part 5: Family T (Turbines)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
hydraulic fluid dehydrator
self-contained system designed to perform the function of water removal from a bulk supply of hydraulic fluid

3.2
hydraulic fluid water saturation level
water concentration level, at a given temperature, beyond which the hydraulic fluid is unable to dissolve any additional water

Note 1 to entry: Any addition of water beyond this limit results in free water or an emulsion formed.

3.3
safety data sheet
SDS
specification sheet defining physical aspects, characteristics and health and safety data for a substance

3.4
relative hydraulic fluid water saturation level
% saturation
hydraulic fluid actual water concentration divided by its water saturation level

Note 1 to entry: Expressed as a percentage.

4 Symbols

The graphical symbols used in this document are in accordance with ISO 1219-1.

5 Principle of test

The hydraulic fluid dehydrator is connected to the test rig containing a volume of test fluid that is related to the rated flow of the dehydrator. The dehydrator and a circulating pump are switched on and the test fluid temperature is raised to the test temperature of 50 °C. With the dehydrator isolated and the circulation pump on, a portion of the test fluid is contaminated to give a water concentration in the rig of 3 % by weight. The test fluid and water are emulsified using a water mixer and then added to the reservoir. Dehydration of the test fluid is initiated and samples of test fluid are regularly taken for water content analysis and the dry-up is monitored. The process continues until the moisture level is below 20 % of the test fluid saturation level. The test is carried out in an environment controlled to a temperature of between 22 °C and 25 °C and moisture content of (55 ± 15) % relative humidity (RH). The performance of the dehydrator is based upon the time required to remove free and dissolved water expressed in a three-part code.

6 Apparatus

6.1 General

The test set-up shall incorporate the following design characteristics. See Annex A for a typical test circuit that provides satisfactory results.

6.2 Test fluid reservoir, incorporating the following features.

6.2.1 It shall be of cylindrical form with a conical bottom whose included angle is between 60° and 90°.

6.2.2 The test fluid shall be drawn from the outlet at the centre of the conical bottom and returned via a hose or pipe to the reservoir. The return shall discharge below the fluid surface and be fitted with a diffuser.

6.2.3 It shall be of sufficient size to hold the test fluid volume required, based upon the dehydrator flow rate. The total test fluid volume, V, shall have a value in litres numerically equal to three times the dehydrator flow rate, q, expressed in l/min. A tolerance of ±10 % is permissible for the test fluid volume, but the actual volume shall be measured and recorded within an accuracy of ±3 %.

A number of reservoirs may be required to cover the range of dehydrators to be tested using this document.

NOTE The circulation time (time = V/q) is set at 3 min to be representative of service conditions and to provide a suitable time for the conduct of the test.

6.2.4 It shall have a lid to cover the opening, but with a suitable opening to allow for the returned sample flow.

6.3 Circulation pump

6.3.1 It shall be a positive displacement type suitable for the required circulation pressure and fitted with a relief valve, either integral or external.

6.3.2 It shall have a variable flow with a maximum of at least twice the flow rate of the dehydrator under test.

6.4 In-line heater, capable of maintaining the test fluid temperature within the limits detailed in Table 1. If the heating elements in contact with the test fluid are electric, the energy density at the surface of the elements shall be no more than 3 W/cm^2. It shall have a safety shut-off thermostat to prevent overheating the test fluid. The installation of a safety switch which disconnects the heater in case of no or low flow through the heater is recommended. Insufficient flow could lead to local overheating of the test fluid.

6.5 Temperature controller, incorporating a temperature sensor that drives a control circuit to maintain the test fluid temperature within 2 °C of the set point.

6.6 Temperature sensor, mounted in the suction line leading to the pump.

6.7 Water sensor (WS), of the thin-film capacitance type that is capable of detecting the relative water saturation level of the test fluid. The water sensor shall be installed through a port in a vertical section of the pipe work in the suction line to the pump.

6.8 Interconnecting pipe work, suitably sized to promote good mixing conditions and constructed such that dead zones or quiescent areas where water could settle out are eliminated. Mixing conditions are ensured when the Reynolds number (Re) is >3 000 in a multi-purpose rig; however, this might not be possible. In these cases, the pipe runs should be kept to a minimum and a mixer/valve interspersed where long pipe runs exist. The design of the reservoir and other test equipment should allow for easy draining of the system, including the installation of drain valves at the lowest points.

6.9 Water mixer, used in the preparation of the test contaminant and fitted with an emulsifying head. The size of the dispersion blade shall be suitable for the volume to be mixed.

NOTE A dispersion blade of 100 mm diameter, rotating at 5 000 r/min minimum, has proved satisfactory for mixing volumes of up to 10 l.

6.10 Karl Fischer (KF) titrator, for determining the absolute water concentration of the fluid samples obtained during the test. The compatibility of the KF reagent with the test fluid shall be confirmed before testing.

6.11 Sampling valve, for the extraction of test fluid samples during the test. The valve shall conform to ISO 4021 and be suitable for low pressure locations. It is recommended that the valve outlet be piped back to the reservoir to provide a continuous flow as this overcomes the need for repeated flushing cycles.

6.12 Sample bottles, for the analysis of samples of test fluid during the test.

They shall**:**

— have a threaded cap and internal seal;

— have a volume between 100 mL and 300 mL;

— be cleaned to remove all traces of previous fluids and be free of moisture;

— be a clear glass bottle with a flat bottom.

6.13 Syringe, for dispensing samples of test fluid into the KF titrator. It shall be clean and dry and calibrated if volumetric measurements are used.

6.14 Test fluid, ISO VG 32 grade mineral oil conforming to L-TSA in accordance with ISO 6743-5 (see Annex B for the specification). A SDS shall be made available. (See Annex C for test fluid quality check information.)

NOTE This test fluid can be re-used.

7 Accuracy of measuring instruments and test conditions

7.1 Use and maintain measuring instrument accuracy and test condition variations within the limits given in Table 1.

Table 1 — Accuracy of measuring instruments and test conditions

Test parameter	Unit	Instrument accuracy (± of actual value)	Permitted variations in test conditions (± of target value)
Volume	l	3 %	10 %
Gauge pressure	kPa[a]	2 %	5 %
Flow rate	l/min	2 %	5 %
Test fluid temperature	°C	1 °C	2 °C
Environmental moisture content	% RH	1 %	(55 ± 15) %
Environmental temperature	°C	1 °C	22 °C to 25 °C
Water sensor	% saturation	3 %	n/a
[a] 100 kPa = 1 bar			

8 Summary of information required prior to testing

8.1 Manufacturer, part number and serial number of the dehydrator unit to be tested and the effective flow rate.

8.2 Hydraulic fluid, used for the test if different to that specified in 6.14.

NOTE If a different fluid is used, then the performance obtained can only be compared to other dehydrators that have been tested using the same hydraulic fluid under identical conditions.

8.3 Test fluid temperature.

8.4 Vacuum setting and any other user-adjustable dehydrator parameter to be used for the test.

8.5 Sampling frequency for the test, the time interval between samples shall be selected so that at least four samples are obtained from the start to the 100 % saturation point. This is to ensure that this dry-up curve is adequately described. The period between samples can either be selected from previous tests or estimated from the presumed free water removal rate of the dehydrator.

NOTE 1 A sample at the 100 % saturation level is ideal, but not essential, as the time to this level is obtained by interpolation on to the dehydration curve (see 10.3).

NOTE 2 Although sampling below the 100 % saturation level is not required as the moisture level is measured by the water sensor, samples can be taken.

8.6 Temperature and relative humidity (% RH), in the vicinity of the dehydrator. If the dehydrator involves the introduction of air into the system, the air inlet to the dehydrator shall be used as the location for these measurements. See Table 1 for test conditions.

9 Dehydrator performance test

9.1 Preliminary preparation

9.1.1 Ensure that the total fluid volume that is required for the performance test has been accurately determined. If not, perform this function on the fill with test fluid in 9.1.6. Any filter element shall be removed from the purifier, as they could have a negative impact on the dewatering efficiency, e.g. due to cellulose-based elements that will absorb water. Only metal mesh suction strainers are acceptable.

9.1.2 If the dehydrator and test rig already contain either previously used test fluid or a hydraulic fluid meeting, the requirements as stated within 6.14, continue to 9.1.6, otherwise proceed to 9.1.3.

9.1.3 If the dehydrator and test rig contain any other hydraulic fluid, completely drain both the dehydrator and test rig. The fluid may be retained for other purposes, if required. Reconnect the purifier to the test rig and add sufficient test fluid (6.14) into the reservoir so that all internal wetted surfaces are flushed with test fluid when both pumps are running. Run the pumps and heater until the normal test temperature (50 °C) is reached. Ensure that all bypass lines, relief valve lines and sample lines are flushed.

NOTE If any of the apparatus contains hydraulic fluid of higher viscosity grade than the test fluid, it might be necessary to flush using the test fluid at the higher temperature of 60 °C.

9.1.4 After flushing, completely drain both the dehydrator and test rig, disconnect hoses and pipe work, if necessary and discard the fluid. Take the necessary precautions for handling hot liquid.

9.1.5 Repeat the drain and flush as per 9.1.3 and 9.1.4.

NOTE Failure to flush and clean thoroughly can lead to spurious results and problems such as foaming of the test fluid.

9.1.6 Reconnect all hoses and pipe work, isolate the dehydrator and fill into the reservoir the volume of test fluid calculated in 6.2.3 calibrating the test facility during this process if required.

9.1.7 Start the circulation pump on its lowest flow and purge the circulation loop of air by gradually increasing the flow rate to twice the dehydrator's rated flow.

NOTE If the circulation pump is not adequately mixing the test fluid, as shown by a non-agitated smooth appearance of test fluid's surface in the reservoir, then a propeller type stirrer can be used in addition for greater mixing action.

9.1.8 Start the dehydrator. Record or measure the dehydrator flow rate. Adjust the temperature controller as needed to achieve the test temperature within the limits given in Table 1.

9.2 Addition of water to the test fluid

9.2.1 Calculate the volume of water required to achieve a concentration of 3 % by volume of the total test fluid in the test rig. Assume a density of the test fluid of 850 kg/m^3 for this calculation.

9.2.2 Add the amount of water calculated in 9.2.1 to a suitable clean and dry vessel containing the test fluid in a ratio of 1:3 (1 part water, 3 parts test fluid by volume).

NOTE Demineralized water is used to contaminate the test fluid and eliminate any possible interaction by mineral salts on either the water removal characteristics or the KF analysis.

9.2.3 Mix the two fluids using the water mixer (6.9) until a homogeneous mixture is formed, with mixing continuing for a minimum of 15 min even if a homogeneous mixture is achieved sooner. The homogeneous emulsion shall have a uniform appearance and there shall be no visible free water dispersion, as is evident from light coloured spherical droplets in the liquid phase.

9.2.4 Switch off the dehydrator and close the isolator valves. Add the emulsion to the reservoir while the circulation pump is in operation to ensure complete dispersion of the water within the test fluid in the reservoir. Rinse the vessel with a few litres of hydraulic fluid from the reservoir to ensure that all the water is transferred.

9.2.5 Run the circulation pump through the temperature control loop to thoroughly mix the water/test fluid emulsion in the test fluid reservoir. This mixing shall be conducted until a completely uniform test fluid appearance is achieved, with mixing continuing for a minimum of 20 min even if the required fluid appearance is achieved sooner.

9.2.6 Open the sample valve to flush the sample line into the reservoir, then take a sample of test fluid and immediately analyse it for water content (see Annex E). Start the test if the water content is at the target value of (3 ± 0,3) %.

9.2.7 If the water content is out of the limits in 9.2.6, continue mixing for an additional 15 min and resample. If a further sample does not meet this criterion, investigate the reason for the discrepancy between the desired and measured concentration. Consider the following:

— measured volumes of the reservoir and residual volume in the dehydrator are incorrect;

— water volume measured incorrectly;

— water is settling in the test rig.

Rectify as appropriate before performing further tests.

9.3 Dehydrator test procedure

9.3.1 Open the isolation valves of the dehydrator and start both the dehydrator and the timer. Record all relevant parameters on the instruments provided on the dehydrator and the test rig.

9.3.2 Obtain a sample of the test fluid from the sampling valve after 5 min of running the dehydrator.

9.3.3 Obtain additional samples at the intervals selected in 8.5 and analyse them in accordance with Annex E. Record the sample time and all other parameters from the instruments provided on the dehydrator and the test rig each time a sample is taken.

9.3.4 Record the times at which the WS indicates 85 %, 60 %, 35 % and 20 % of saturation. Terminate the test when the indicated % saturation is below 20 % and note this value.

9.3.5 Record any unusual occurrence during the test, such as an electrical trip, alarm conditions, test fluid leaks, excessive fluid mist in the exhaust, etc.

10 Reporting

The results of the dehydrator water removal performance test shall be reported on a results sheet containing, as a minimum, the information shown in the example results sheet in Annex D.

10.1 Calculate the number of passes (n) through the dehydrator for each data set using Formula (1):

$$n = q \times t / V \tag{1}$$

where

q is the dehydrator flow rate, in l/min;

V is the total volume (dehydrator and reservoir, in l);

t is the lapsed test time, in min.

10.2 Using the test data, plot a graph on linear axes of parts per million by weight of water (ppmw) versus number of passes through the dehydrator for the data up to the 100 % saturation point and connect the data points with the best fit curve, as shown in Figure F.1.

Draw horizontal lines representing:

a) the 2 % water concentration level;

b) the 1 % water concentration level;

and obtain the number of passes from the plot at the 2 % water concentration level (N_1) and the 1 % water concentration level (N_2).

NOTE 1 Incomplete mixing at the start of the test can result in the first data point being off the general trend.

NOTE 2 Plotting all of the test data results in compression at the dry-end can give inaccurate interpolation.

10.3 Plot a graph on linear axes of % of saturation versus number of passes through the dehydrator for the WS data as shown in Figure F.2 and connect the data points with the best fit curve. Extrapolate the trend of the curve and establish the number of passes to reach the 100 % saturation point (N_3). Also obtain the number of passes at the 20 % of saturation point (N_4) either by recording or interpolation onto the curve.

10.4 Calculate the number of passes to achieve the following:

a) optimum free water removal = $N_F = (N_2 - N_1)$;

b) removal to saturation = $N_s = (N_3 - N_1)$;

c) removal from 100 % to 20 % saturation levels $N_{20} = (N_4 - N_3)$.

10.5 Express the water removal capabilities (WRC) of the dehydrator as a three-part code giving the number of passes obtained in 10.4 rounded up or down to the nearest pass and separated by an oblique ('/'). The code shall be prefaced by ISO 18237, as: WRC = ISO 18237 N_F /N_S/$N_{20.}$ For the example given in Annex F, the code is WRC = ISO 18237, 7/29/11.

10.6 Calculate the free water removal rate (Ra) in l per 24 h based upon the time to reduce the water concentration from 2 % to 1 % as follows in Formula (2):

$$\mathrm{Ra} = \frac{V}{100} \times \frac{1\ 440}{(t_2 - t_1)} = \frac{14{,}4 \times V}{(t_1 - t_2)} \tag{2}$$

where

V is the total test fluid volume, in l;

t_1 is the time when the water concentration is 2 %, in min;

t_2 is the time when the water concentration is 1 %, in min.

For the example in Annex D: t_2 = 45,6 min, t_1 = 23,4 min, hence Ra = 162 l of water per 24 h. The t_1 and t_2 time values are calculated based on the number of passes obtained from plot in Annex F.

t (min) = (v x Number of passes) / q (l/min).

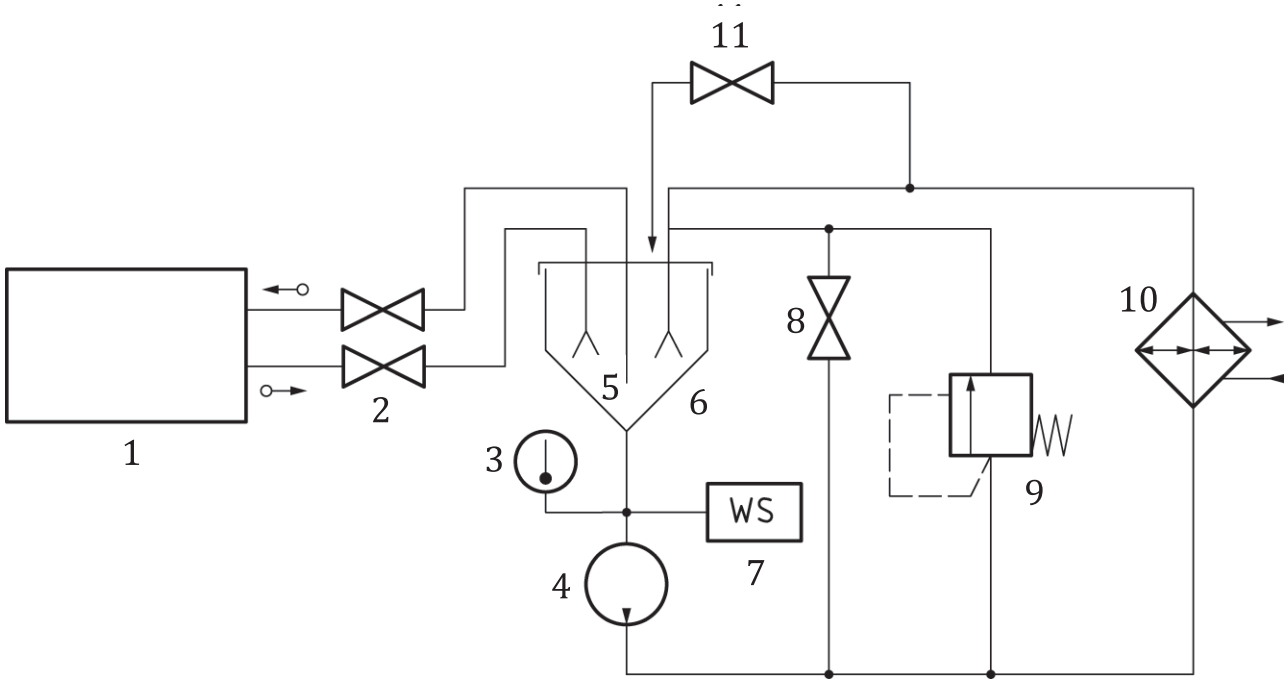
11 Identification statement

Use the following statement in test reports, catalogues and sales literature when electing to comply with the document.

Dehydrator performance measured in accordance with ISO 18237.

Annex A
(informative)

Test circuit



Key

1 test dehydrator
2 isolation valves
3 temperature transducer
4 circulation pump
5 flow diffuser
6 test fluid reservoir
7 water sensor
8 bypass valve
9 system pressure relief valve
10 temperature controller (heat and cool)
11 sample valve

Figure A.1 — Suggested dehydrator test circuit

Annex B
(normative)

Test fluid specification

B.1 Specification

The test fluid shall be an ISO VG 32 grade mineral oil conforming to L-TSA in accordance with ISO 6743-5. An SDS shall be available.

NOTE 1 This type of hydraulic fluid has been successfully used in steam turbines for a long period and has demonstrated chemical stability in the presence of significant concentrations of water contamination. The use of hydraulic fluids with a higher additive content can lead to additive precipitation and variability in the hydraulic fluid's water release properties.

NOTE 2 Hydraulic fluids with certain additives can affect the accuracy of some Karl Fischer instruments.

B.2 Properties of finished test fluid

The test fluid shall have the following characteristics.

a) Viscosity

   1) At 0 °C (min): (260 ± 25) mm^2/s

   2) At 40 °C (min): (32 ± 3,2) mm^2/s

   3) At 100 °C (max): (5,5 ± 1,0) mm^2/s

b) Viscosity index minimum: 95

c) Density at 15 °C: 850 kg/m^3

d) Flash point with closed cup (min): 160 °C

e) Acid number (max): 0,1 mg KOH/g

f) Demulsibility, at 54 °C, time to 3 mL emulsion, (max): 10 min

h) Water content (max): 100 µg/g

i) Air release: 50 °C, 2 min

Annex C
(informative)

Test fluid quality checks

C.1 General

The ability of a hydraulic fluid to release water is dependent upon its base stock, chemistry, the type and quantity of additives used and the degree of degradation through oxidation. For a standard test, all of these factors should be kept constant so that the results can be compared on the same basis. One way of achieving this is to replenish the test fluid after each test, but this increases the costs per test considerably, if regular testing is carried out. Even then there is no guarantee that the hydraulic fluid has identical characteristics as base stocks, hence additive levels vary to keep the fluid's overall performance within limits.

The test fluid used in this document has been selected based on its chemical stability in the presence of relatively large amounts of water, but there can still be a very small reduction in characteristics on a test-to-test basis. With time, this can become significant and, if not detected, the accuracy of the test can be compromised. It is therefore essential that the test fluid be tested on a regular basis, the results are compared to the design value and the test fluid replaced when these are exceeded. Table C.1 gives the parameters to be measured, the test method, the design value and allowable limits.

C.2 Test fluid parameters to be measured

Table C.1 — Allowable limits for test fluid parameters

Parameter	Unit	Design value	Allowable limits
Viscosity at 40 °C	$mm^2/_s$	32	±6,0
Viscosity index	none	95	115 max
Density at 15 °C	kg/m^3	850	±40
Neutralization number in accordance with ASTM D974 or DIN 51558	mg/KOH-g	0,1	0,2 max
Demulsity at 54 °C time to 3 mL emulsion in accordance with ASTM D2711–11	min	10	+2,0
Air release at 50 °C in accordance with DIN 51381	min	2	4 min max
100 % saturation level at 25 °C (see C.4.1)	ppmw	measured when new	±20 % change

C.3 Frequency of test fluid quality checks

The frequency of quality checks depends upon the frequency of use and the severity of testing if non-standard tests are performed. It is recommended that the frequency of testing is "high" initially, i.e. after every five standard tests on the same test fluid. The results are trend plotted and then the frequency changed on the basis of the trend in results, i.e. the frequency reduced if the change is insignificant compared to the allowed limits and increased if the change is significant. Statistical process control (SPC) techniques are useful here.

C.4 Quality checks on the saturation level of the test fluid

C.4.1 Fluid parameters test

Although Table C.1 states that this test is performed at 25 °C, it can be done at any convenient test fluid temperature to suit the local environment, provided that the same temperature is used throughout.

C.4.2 Apparatus

The following is required.

C.4.2.1 Clean and dry sample bottle (**6.12**). It is recommended that a secondary cap be made to hold the WS probe while the measurements are being made.

C.4.2.2 Hot plate with magnetic stirrer.

C.4.2.3 Plastic stirring bar, compatible with the test fluid.

C.4.2.4 Bottle roller or ultrasonic bath.

C.4.3 Procedure

a) Extract a sample of test fluid from the desired source and collect it in the sample bottle. If the source is the test reservoir, ensure that the sample is extracted while the test fluid has been circulating for at least 5 min. If the sample is taken from a container, agitate the container to mix the contents before extracting the sample. If possible, sample from the middle of the container.

b) If the sample is not to be analysed immediately, put it on a bottle roller until analysis.

c) If a bottle roller has not been used, prepare the sample in accordance with E.7.

d) Before analysis of water content, rinse the outside of the stirring bar with clean solvent, uncap the sample bottle and insert the stirring bar. Take a syringe sample of the test fluid for Karl Fischer analysis at this time and recap the sample bottle with the specially made cap containing the WS probe. Position the probe about 15 mm above the stirring bar.

e) Put the sample bottle on the hot plate and increase the speed of the magnetic stirring so that the bar moves the test fluid without causing a vortex or generating air. Increase the temperature to the desired value as recorded by the WS temperature probe.

f) When the temperature is stable (less than 0,2 °C change per min), take five consecutive readings of % saturation and temperature and average the results.

g) Perform the Karl Fischer analysis on the syringe sample and divide the result in ppmw by the averaged WS reading. Multiply the result by 100 to obtain the ppmw water value at 100 % saturation. For example: if the fluid sample has 40 ppmw water at 60 % saturation (as measured by the WS), the ppmw value at 100 % saturation is 66,7 (40/60 × 100).

Annex D
(informative)

Test results sheet giving example data

Dehydrator information				
Manufacturer:		P/N:	S/N:	Flow rate, *q* (L/min):
Purifier Co:		VD 123	1234	83,3
Vacuum set-point (mbar): 255 mb				
Test fluid information				
Fluid name:	Manufacturer:	Date of manufacture:	Batch no:	Viscosity grade:
ISO VG 32	Oil Corp	2011–3-27	B2411–6	ISO VG 32
Fluid water saturation limit (ppmw): 183 at temperature (°C): 50				

Test parameters/conditions				
Test fluid volume, *V* (l)		Circulation pump flow rate (l/min)	Fluid temp (°C)	Ambient air temp (°C)
250		150	50	23
Ambient air RH (%)	Initial water content (%)	Final water saturation (%)	Water added (L)	
45	3,1	19,4 %	7,8	

Test data				
	Time, *t* (min)	Passes through the dehydrator[1]	Water concentration (ppmw)	Water (% saturation)
Sample #1 - Initial	5	1,7	282 622	>100
Sample #2	35,8	11,9	123 461	>100
Sample #3	71,7	23,9	32 984	>100
Sample #4	107,5	35,8	389,8	>100
Sample #5	116,4	38,8	157	85
Sample #6	142,4	41,4	111	60
Sample #7	135,9	45,3	64,8	35
Sample #8 - Final	147,0	49,0	37,0	20
[1] number of passes = t*q/V				
	2 % water content	1 % water content	100 % saturation	20 % of saturation
Time (min)	23,4	45,6	112,2	146,4
Number of passes	7,8	15,2	37,4	48,8
WRC (see 10.5) = ISO 18237 = 7/30/10		R_a – Free water removal rate (see 10.6) = 162 l/24 h		
Miscellaneous test information: none				

Annex E
(normative)

Sampling and analysis procedures

E.1 All samples shall be taken from the sample valve, see Figure A.1. The valve shall conform to ISO 4021 and be configured for sampling from low pressure lines. The configuration shown in Figure A.1 provides a continuous sample flow so that flushing prior to sampling is not required.

E.2 Before the start of the dewatering tests, open the sampling valve and regulate the flow rate to between 200 mL/min and 500 mL/min.

E.3 Take the sample in the following manner.

a) Uncap the sample bottle and immediately collect the sample and fill the sample bottle to approximately 50 % of its volume.

b) Immediately cap the sample bottle and vigorously shake the sample bottle to equalize the moisture of the sample bottle to that of the test fluid and then discard the sample into the waste container.

c) Repeat once more if there is any doubt about the condition of the sample bottle and then take the sample, filling the sample bottle to 70 % of its volume and then cap the bottle.

d) Immediately afterwards, record the time of the final sample and any other pertinent test readings.

e) Label the bottle with a generic code and the time of collection.

f) After collection, place the sample bottles on a bottle roller and only take off prior to analysis.

E.4 The samples shall be analysed within one hour of collection. If this is not possible, then the test fluid shall be agitated prior to analysis in order to re-mix the water and test fluid.

NOTE Where the test fluid has a high viscosity, it can be necessary to heat the samples to achieve adequate remixing.

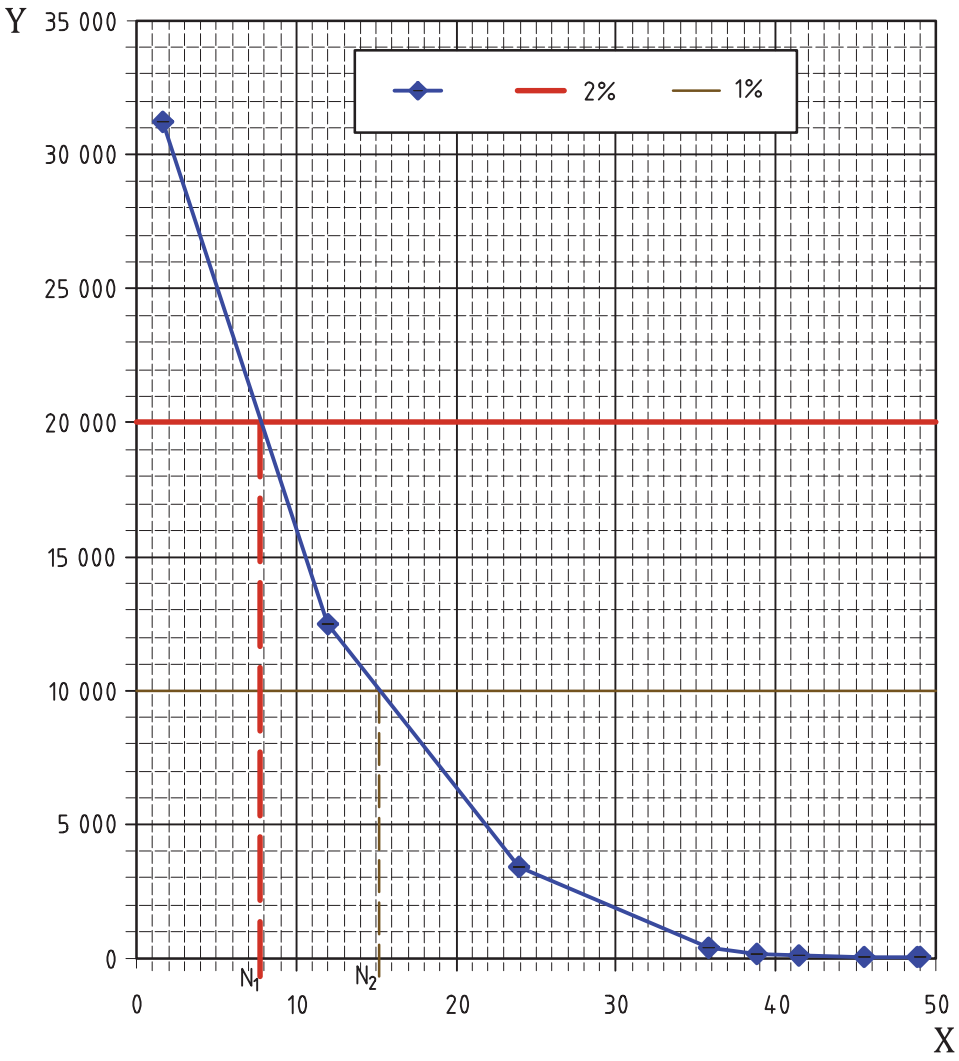
E.5 If the sample has been standing, shake the sample bottle by hand for 1 min followed by treatment in an ultrasonic bath for 30 s, before obtaining a sample for analysis using the syringe.

E.6 The type of reagent to be used in the Karl Fischer apparatus for water analysis shall be appropriate for the test fluid. Consult the manufacturer of the Karl Fischer apparatus and the reagent supplier as required.

E.7 Uncap the bottle and extract a sample for water content analysis using a dried syringe. Analyse the sample for water content by Karl Fischer titration in accordance with ISO 760. Perform two consecutive analyses and compare the results. If a deviation greater than 5 % is noted between the two analyses, the analysis shall be repeated and the two closest results averaged. Record the results. If inconsistent results are still evident, the reason for the discrepancy shall be investigated, including the possibility of reagent exhaustion.

Annex F
(informative)

Example graph

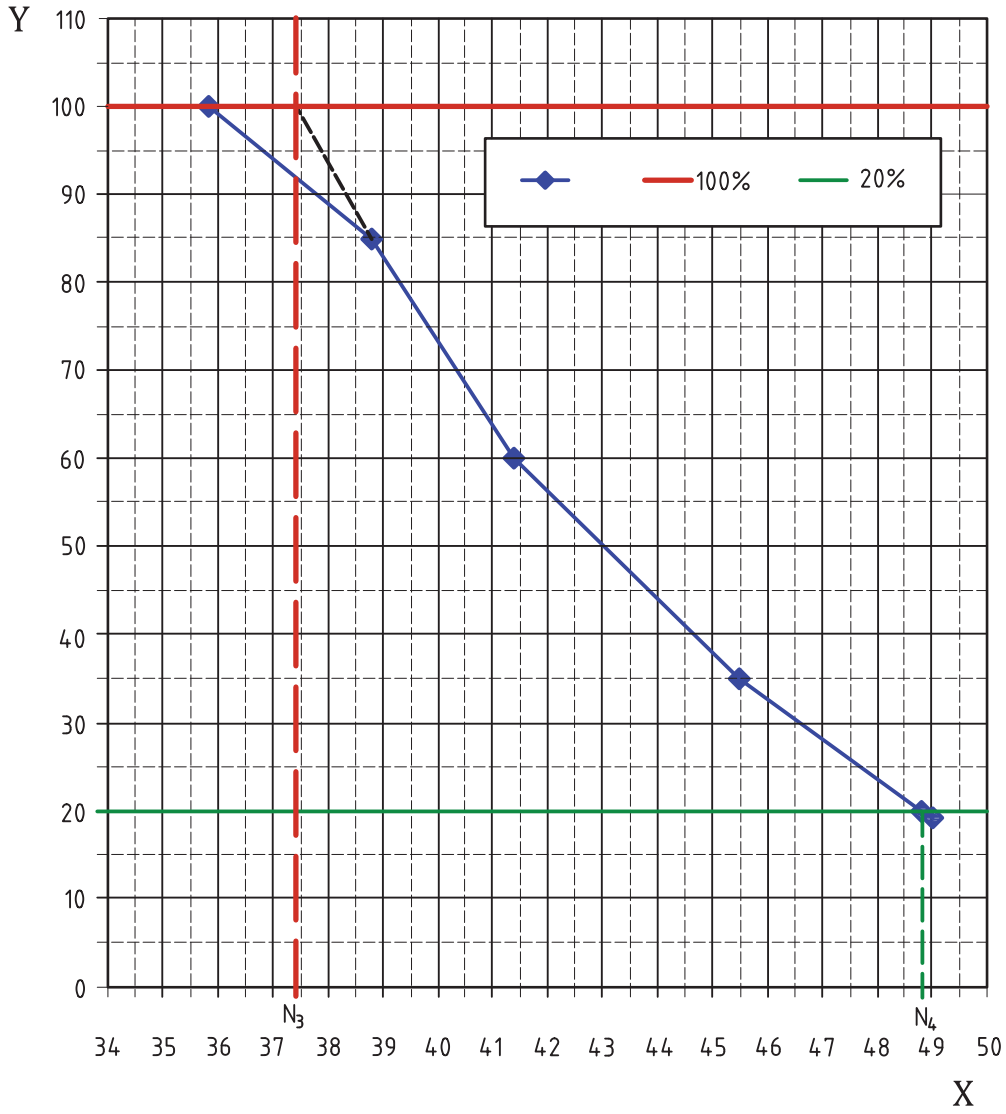


Key

Y water content (PPMw)

X number of passes through the dehydrator

Figure F.1 — Example of free water removal graph



Key

Y % of saturation

X number of passes through the dehydrator

Figure F.2 — Example of extrapolation to 100 % saturation

Bibliography

[1] ISO 6743-4, *Lubricants, industrial oils and related products (class L) — Classification — Part 4: Family H (Hydraulic systems)*

[2] ASTM D974, *Standard test method for acid and base number by color-indicator titration*

[3] ASTM D2711-11, *Standard test method for demulsibility characteristics of lubricating oils*

[4] DIN 51558, *Testing of mineral oils; determination of the neutralization number, colour-indicator titration*

[5] DIN 51381, *Testing of lubricating oils, governor oils and hydraulic fluids; Determination of air release properties*

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