

TSG Recommendation 2014-01-27, replacing earlier versions

TSG recommends

Quantified targets for hydraulic systems in forest machines



The TSG recommendation *Quantified targets for hydraulic systems of forest machines* sets standards for various components of the hydraulic systems. It should be seen as a supplement to other existing standards, criteria and requirements applicable to the machine system as a whole. It is important that new forest machines fulfill the environmental requirements and other standards that apply in Swedish forestry. As far as possible, the structural elements shall minimize risks to human health.

The TSG recommendation presupposes that:

- forest machines are designed for, and calculations based on, an operating time of 20,000 hours for a complete machine,
- the total price of the machine shall not be significantly affected,
- the total costs of maintenance over the useful life time of the machine shall be reduced.

These recommendations should be incorporated in new designs. Machine operators and service engineers should be trained in 'Modern Hydraulics'. Service providers and designers should be certified for hydraulics.

Purpose

The purpose of the recommendations is to create a common platform for Swedish forestry, forest machine manufacturers and users of forest machines with regard to hydraulic systems in current and new machines.

Explanations of parameters included in the table of specifications.

THE HYDRAULIC SYSTEM

Hydraulic system, availability

TSG demands that from 2010, availability must exceed 95 %. A time monitoring system on the machines allows close monitoring and recording of various causes of disruption, thereby providing a measure of hydraulic availability. Such monitoring systems are expected to be installed in all machines from 2010.

The figure shown for 2005 assumes that approximately half of all standstills are caused by a hydraulic component in need of repair. Other standstills are attributable to necessary measures involving other machine components.

The 'hydraulic system' includes various subsystems whose function is based on hydraulics.

Hydraulic system, efficiency

In 2010, total hydraulic efficiency should be greater than 70 % for new machines. One important parameter for the future is to reduce energy consumption, currently comprising diesel fuel. This cost item currently comprises a major proportion of the machine costs. Environmental impact, such as small spillages and emissions, must be improved for new machines.

In 2014/2015, Skogforsk will be working with machine manufacturers to develop a measurement method to determine the hydraulic efficiency in current and new machines.

Hydraulic system, external leakage

All forest machines currently have unacceptable external leakage. In new machines, greater emphasis must be placed on more secure and fewer leakage points in a modern hydraulic system. The total leakage for the individual machine does not include oil change. All conveyance and hydraulic components must be of higher quality. The entire hydraulic system shall have the same type of conveyance components, such as tapping system, spanners and sealing elements, etc. All conveyance systems, such as compressed air, water, lubricants, fire extinguishers, shall have the same type of conveyance components as the hydraulics.

TSG recommends ISO 8434-3 (SAE 1453) or better.

Hydraulic system, cleanliness

For new machines, the system's cleanliness should be stated according to ISO 4406:99, showing particle size classes $>4 \mu\text{m}$, $>6 \mu\text{m}$ and $14 \mu\text{m}$. In order to reduce maintenance costs throughout the useful life of the machine, it is important to keep the quantity of contaminants as low as possible. TSG recommends on-line monitoring.

Hoses and other conductor components: interior surface cleanliness

Hydraulic conductor components should last longer than is the case today. Quality and performance of the conductor components should be chosen with regard to the exterior leakage of the system. All hoses, tubes, adapters, accessories etc. should be firmly connected to the sealing surfaces, whole, undamaged and clean, according to SS 2687, SP Report P004725 or better. All inner tubes and steel pipes in hydraulic hoses should be completely undamaged and clean after cutting. If any type of cleaning is required, this process should not be detrimental to other structural elements of the system.

Hydraulic oil: maximum temperature

The figure shown in the table indicates the temperature of the hydraulic oil in the oil tank during normal operation. The temperature is measured in the middle of the tank.

Hydraulic oil in the system

Basic requirement

The basic requirement for hydraulic oil according to SS 15 54 34 should be fulfilled. The SP examination is an environmental assessment of components in pre-formulated hydraulic oil. TSG recommends additional technical requirements such as minimum levels for oxidation, hydrolysis, water content, air release/foaming properties, as well as air and gas content.

In view of the environmental requirements applicable in Swedish forestry and various forms of certification, it is important that new machines attain current and future environmental targets. Consequently, machine manufacturers and suppliers of various structural elements need to implement development initiatives to ensure that future requirements are met.

The figures apply to used hydraulic oil. Note that the figures do not apply to new oil.

Viscosity increase

Polyolesters are very shear stable and normally retain their viscosity. If the measured values deviate by more than ± 5 cSt, an oil change should be planned.

Measure *hydrolysis* according to RR 1006, in mg KOH/g (equivalent to acid value, TAN).

Measure *water content* according to ASTM 1744 and in ppm. The target is for water content to be less than 100 ppm.

Measure *air release* according to ISO 9120 in minutes for an ISO VG 46 cSt product.

Measure *air percentage by volume* and *gas content* according to a gas analysis, IEC 567, and expressed in %..

Oil with an *iodine value* less than 9 is a saturated ester.

Sensors

Sensors are gauges that can measure water content or water activity, expressed in ppm.

Particles are stated according to ISO 4406:99. The sensors are to be connected to the hydraulic system, allowing on-line measurements. Information from the gauges is to be presented in appropriate form via the computer system in the forest machine.

Training

The Swedish committee for vocational training in the forest sector, SYN, provides a course in Modern Hydraulics primarily intended for machine operators and service technicians.

A training course available for designers and service providers leading to certification in hydraulics. The course is arranged by the Swedish Association for Hydraulics and Pneumatics.

This TSG recommendation is based on the accumulated experience of users (entrepreneurs and forestry companies), researchers and machine manufacturers. TSG's objectives are to state specifications, to provide guidelines, and to set targets. The recommendation should be regarded as a living document and will be amended in line with developments.

Through the compilation of experiences and knowledge from machine manufacturers, users and researchers, TSG hope to further a development of forest machines that will increase productivity, reduce environmental impact and improve the working environment.

Table of quantified targets for hydraulic systems in forest machines

	2001	2005	2010	2015	2020
THE HYDRAULIC SYSTEM					
The machine's hydraulic system: availability, %	90	>93	>95	>96	>96
Hydraulic system: efficiency, %	58	>65	>70	>72	>73
Hydraulic system: own exterior leakage SAE J 1453 ISO 8434-3	För mycket	<0,15 l/h <0,05 l/h	<0,05 l/h <0,02 l/h	<0,01 l/h	<0,01 l/h
Hydraulic system: cleanliness according to ISO 4406 ISO/FDIS 4406:99	<15/11	<13/10/7	<10/8/5	<10/8/5	<10/8/5
Conveyance components: internal cleanliness					
Number of particles/cm ² per grain size interval	100 000	5 000 5–15 µm 1 000 5–15 µm	2 500 5–15 µm 500 5–15 µm	500 6–14 µm 100 6–14 µm	500 6–14 µm 100 6–14 µm
hoses/miscellaneous SS 2687	5–15 µm				
Pipe plugs of lamellar type, similar or better.					
Hydraulic oil: maximum working temperature in the tank			< 70°	< 70°	< 70°
HYDRAULIC OIL IN THE SYSTEM					
<i>Hydraulic oil: basic requirement according to SS 155434, environmentally acceptable, as follows</i>					
Viscosity-increasing oxidation, Baader 110° B level.	16 %	<5 %	<2 %	<2 %	<2 %
Hydrolysis increase, mg/KOH RR 1006	2	<1	<0,5	<0,5	<0,5
Water content, ppm ASTM D-1744	300–500	<100	<150	<300	<300
Air release, 46 cSt ISO 9120	9	<2	<1	<1	<1
Air volume by percentage, gas analysis, IEC 567	8 %	<2 %	<1 %	<1 %	<1 %
Hydraulic oil: iodine value stated			Ja	Ja	Ja
Sensors in the system			Ja	Ja	Ja
TRAINING IN HYDRAULICS AUTHORIZATION		'Modern Hydraulics'		'Modern Hydraulics' Hydraulics Certificate	'Modern Hydraulics' Hydraulics Certificate



References

This recommendation is based on the following references:

Standards

SAE J-1453:2 O-Ring Face Seal.

ISO 8434-3: 2005 Metallic tube connections for fluid power and general use – Part 3: O-ring face seal connectors.

ISO 4406:1999 Hydraulic fluid power – Fluids – Method for coding the level of contamination by solid particles.

SS 2687 Renhetsteknik – Ytors renhet i system.

SS 155434 Miljöanpassade hydrauloljor.

Baader 110 degrees, level B.

RR 1006.

ASTM D1744-92 Standard Test Method for Determination of Water in Liquid Petroleum Products by Karl Fischer Reagent. NB. Withdrawn.

ISO 9120:1997 Petroleum and related products – Determination of air-release properties of steam turbine and other oils – Impinger method.

IEC 567/ASTM D 3612 Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.

SMP Reports:

Maskinprovningarnas Miljöoljeprojekt – Passar miljöanpassad olja utan teknikanpassning?
Rapport Dnr 30:28-90, Statens Maskinprovningar, Umeå, 1994.

Miljöanpassade hydraulvätskor 1995–1997.

Projekt 1. Rapport nr: PU 041/95, juni 1997.

Miljöanpassade hydraulvätskor 1997–1999

Projekt 2. Rapport nr: PU 1213/97, juni 1999.

Miljöanpassade hydraulvätskor 1999–2001.

Projekt 3. Rapport nr: PU 19233/99, juni 2001.

Miljöanpassade hydraulvätskor 2001–2003.

Projekt 4. Rapport nr: PU 37076/01, oktober 2003.

Miljöanpassade hydraulvätskor 2003–2005

Projekt 5. Rapport nr: PU 61350/03, maj 2005

Miljöanpassade hydraulvätskor 2006–2008.

Projekt 6. Rapport nr: P700115, november 2009.

Tekniska Samverkansgruppen, TSG (Technical Collaboration Group represents the users of forest machines, from contractors to the major forest companies and Skogforsk researchers in this area, the Hydraulics group is one of several working parties of TSG.

The aim is to identify problems and possibilities of current forest technology and to endorse developments towards effective, gentle and profitable forest technology through communication with the manufacturers of forestry machines and equipment.