



Guidelines for flushing of mineral oil hydraulic systems

矿物油液压系统投油指导说明书

This guideline is TTS standard, and provides guidance applicable to all TTS mineral oil system..

本指导手册为 TTS 通用标准，适用于使用矿物油液压系统的通道系统。

If not especially explain, the cleanness of TTS hydraulic system should reach ISO4406 17/13.
若无其他注明，通常 TTS 液压系统的清洁度要求为：ISO4406 17/13

By experience it is noted that the local Site Engineers and others conducting the flushing procedure may be lacking in relevant system flushing experience. Adherence to these Guidelines will enable them to avoid many of the pitfalls and to accomplish the aim of the procedure.

根据经验，现场工程师和其它投油工作的管理者往往缺乏投油清洗的相关经验。参考本指导工艺将有助于避免投油中出现的缺陷，并实现投油的目的。

After flushing, the cleanness report should be delivered to TTS before commission.
管系清洗结束后系统调试前，应向 TTS 提供清洁度的检验报告。

1. INTRODUCTION

简介

- 1.1 Flushing is a procedure that is vital to quality secure operation and life of a hydraulic system. An incomplete flushing program can be fatal with reference to rapid wear of components, malfunction and breakdowns.

投油清洗的目的是为了清除在安装过程中进入液压管内部的污染物。它是保证液压系统安全可靠地操作及较长使用寿命的非常重要的一环。不完善的投油清洗过程将导致组件严重磨损、故障甚至系统瘫痪。

- 1.2 The range of types of hydraulic system is very diverse, both in size and complexity. A careful judgement must be exercised for each project related to how to erect suitable temporary connections (hoses), isolated by temporary ball valve in order to get sufficient flow rate during flush.

液压系统根据尺寸及复杂性的分类有很多种。针对不同的项目，为了达到理想的效果，必须考虑使用合适的临时接管或球阀，将系统分隔为多个部分或回路，依次进行投油清洁。

- 1.3 Common pipe system Data: Pipe dimensions normally used max Φ out. 42mm. Working pressure max 250 bar. Cutting ring coupling system is normally used, other system on request. Welded pipe systems, necessary pressure test and acid clean must be



done in workshop before installation on board.

管系通常数据：液压管外径通常不大于 42mm，工作压力最大为 250bar，使用卡套接头（其他接头形式请询问 TTS）。焊接式管系必须先车间内进行压力试验和酸洗等工艺后才能上船安装。

- 1.4 Special flushing pump unit should be used. Sufficient capacity with reference to following requirements: Oil flow – oil pressure – filter – tank volume – heating / cooling. In order to reach flushing standard ref. ISO4406 class 17/13, sufficient flushing result is optimized if a flushing flow corresponding to $Re_n=3000$ is used (see enclosed flushing flow document). A full flow return oil filter 10 micron absolute shall be used.

应使用专用的投油泵组进行系统的清洗。投油泵组需要达到足够的流量-压力-滤器-油箱容量-加热/冷却能力。投油后需要达到 ISO4406 17/13 等级。为了达到好的投油效果，建议投油时液体的雷诺数 $Re_n=3000$ （见附表）。在回油管上需要使用一个绝对精度为 10 微米的回油滤器。

2. SYSTEM PREPARATION

系统准备

- 2.1 All components delivered by TTS should be supplied in a seal and clean condition. Any contamination found to be reported to TTS supervisor.

TTS 供应的液压元件都应该是处于密封/清洁的状态。如果发现组件密封不洁净，请报告 TTS 服务工程师。

- 2.2 Particular attention should be given to piping, which should be free from scale, rust, flux etc. Piping not in the clean condition should either be rejected and replaced or cleaned before assembly.

注意管子上不能有剥落、铁锈及焊渣等痕迹。液压管如果未达到清洁状态，应当拒绝使用，并在投油清洗之前予以更换或清洁。

- 2.3 System components which may present a restriction to the flow, be damaged by or restrict the high flushing flow should be bypassed by suitable make-up pieces. Components disassembly should be stored in clean space.

系统中的组件投油时都必须使用临时管跨接或旁通掉。这是因为它们如果参与投油过程可能会减低清洗油液的流速或形不成清洗回路；另外还有可能在投油过程中被污染。拆下的组件应妥善安放。

- 2.4 In most cases only the simplest system can be flushed in just one operation. The system should be divided into sections or loops, these sections being flushed in sequence.

大多数情况下只有非常简单的系统才可以采用一次清洗方式清洁。一般应当在清洗前预先进行设计，将系统分隔为多个部分或回路，依次进行投油清洁，保证每一路管子都能清洗到。

3. FLUSHING EQUIPMENT

投油设备

- 3.1 The flushing rig should comprise pumps, tank, filters and hose connections.

投油设备由泵、油箱、滤器和软管等组成。

- 3.2 The displacement of flushing pump should make passing fluid through the system at a flow much higher than that during normal operation, the fluid to be reached to turbulent. Then this fluid can remove contamination from the inside of pipes. The pumps should incorporate adjustable relief valves to be set at a pressure above that required, passing the full pump flow through the system to be flushed. The required pump flow as well as pressure capacity is defined in the next section.

投油泵的排量应能使清洗管子内的流速比正常操作时大得多，达到紊流流量。这样快速流动的液体可以带走污染物。泵出口应当设置可调节的溢流阀，设定压力应当高于投油中的压力损失，来保证投油时泵的所有流量都进入管系。投油泵流量和压力的确定请参见下面的章节。

- 3.3 The tank should have a capacity at least equal to three times the pump delivery per minute and preferably of greater capacity than the system to be flushed

油箱的容积至少为投油泵每分钟输出容积的三倍，最好大于参与投油的管系体积总和。

- 3.4 The filters are of disposable element type. Duplex filters are preferred as they permit the changeover to a clean element without interrupting the flushing procedure. The filters should incorporate clogging indicators, preferably incorporating an audible alarm. An automatic filter bypass is not preferred. The filter size should be selected to pass the specified pump delivery at a low pressure-drop, depending upon type and should have a generous dirt-holding capacity. The degree of filtration should be selected to meet the requirements of the system to be flushed. Filtration grade recommended element type to be max. 10 micron absolute.

滤器应当为可任意更换的形式，最好使用双联滤器，因为此种滤器可以在更换滤芯时不中断投油过程。滤器应当安装污染监测器，最好具有声光报警功能。不允许滤器具有自动旁通功能。滤器的大小应当根据投油泵的流量来选择，压力损失应该尽可能小，应当适当考虑不同型号滤器的纳垢容量。过滤精度应根据投油管系所需达到的要求来选择，我们建议选用绝对过滤精度至少为 10 微米的滤芯。

4. FLUSHING FLUID

投油油液

- 4.1 The flushing fluid must be compatible with the fluid specified for the system and with the system materials, especially the seals. The fluid should preferably have rust inhibiting and dewatering properties. The fluid specified for the system may be used as the flushing fluid but a flushing fluid of lower viscosity would permit the attainment of turbulent flow at a lower flow of temperature as discussed in para 5.2.

投油时使用的清洗剂必须与系统技术要求相兼容，尤其是密封件。清洗剂最好具有防锈和脱水性质。为了使液体在一定温度下达到紊流状态的流量较低，可以选用粘度比系统正常使用油液低的清洁剂，见 5.2。

- 4.2 The use of synthetic hydraulic oils as the system fluid may present a problem in the choice of a flushing fluid and the advice of the fluid supplier should be sought on

compatibility of the fluids

根据油液供应商的建议，如果使用合成液压油可能会出现碰到一个问题，即必须考虑油液兼容性。

- 4.3 Hydraulic oil, rust inhibited oils of lower viscosity, or special flushing oils can be used for flushing. The special flushing oils which are suitably refined distillates with good solvency power and containing rust inhibitors and additives are used for the removal of system contaminants such as rust preventative compounds and sludge's.

可以使用低粘度的防锈液压油或者特殊的清洗油液。精制清洁油有很强的溶解能力，而且含有防锈添加剂，此添加剂用来排除系统中的污染物，例如可预见的铁锈和乳化物。

- 4.4 Flushing oils containing petroleum solvents such as kerosene or non-petroleum solvents such as carbon tetrachloride and solutions containing water, caustic compounds or other active materials must not be used for flushing.

在投油中禁止使用以下清洁剂：溶解有石油的清洁剂（例如煤油），无溶解石油的清洁剂（例如四氯化碳），含水的腐蚀性化学物及其它氧化剂成分的清洁剂。

- 4.5 The selection of the type of flushing oil to be used should be based on the judgement of experienced personnel after thorough inspection of the system.

投油清洗具体选用何种清洁剂必须经过系统检验后依据个人经验判断。

- 4.6 The following table is a guide to selection of the flushing oil for various contaminants.

根据不同种类的污染物按下表选择清洁剂

Systems 系统	Solids 固体	Rust 铁锈	Rust Prev.	Deterioration Products and Sludge 油液已经乳化
New 新系统	1,2	1,2,3	3	-
In service 处于服务期间的系统	1,2	1,2,3	-	3,2
After Layup 重建系统	1,2	1,2,3	3	3,2

(1) Regular hydraulic oil / 常规液压油

(2) Rust inhibited mineral oil (viscosity less than 40 cSt at 40°C) / 防锈矿物油（粘度在 40°C 低于 40 cSt）

(3) Special flushing oil / 特殊清洁油

5. FLUSHING FLOW AND TEMPERATURE See enclosed charts. Necessary flow capacity with reference to pipe length / dimension, temperature, viscosity.

投油流量和温度见附表，附表提供了不同长度/管径、温度和粘度下所需的投油流量

- 5.1 To ensure that the system is flushed as quickly and efficiently as possible, both fluid

flow and temperature should be as high as conveniently possible. A reasonable flushing max. temperature limit for mineral oils is 55°C, for water-in-oil emulsions and water-glycols it is 40°C.

为了确保投油尽可能快速高效的完成，应该使液体的流量尽可能大并且温度尽可能高。对于矿物油系统合理的最高温度是 55°C，而对于水基乳化油和水乙二醇系统则为 40°C。

- 5.2 The flushing flow should be at least that what is necessary to achieve a turbulent flow. Re 3000 minimum is recommended to reach acceptable flushing time. Flow changes from laminar to turbulent when Reynold Number is greater than 2300 i.e. $Re_n > 2300$. Following formulas show the relation between Flow (Q), Reynolds Number (Re_n), Pipe Internal Diameter (d_i), Kinetic Viscosity (v) and Flow Velocity (v):

投油时液体至少需要达到紊流状态，建议投油时雷诺数 Re 至少为 3000。当雷诺数高于 2300 时，液体将从层流转变为紊流。下面的公式反映了流量 (Q)、雷诺数 (Re_n)、管子内径 (d_i)、运动粘度 (v) 和流速 (v) 之间的关系：

$$Q = Re_n * d_i * \eta * p * 1,5 * 10^{-5}$$

$$V = \frac{Q}{d_i * \pi} * \frac{200}{3}$$

Where

[Q]	= ltr/min	(Flow / 流量)
[Re _n]	= n (dimensionless)	(Reynolds Number / 雷诺数)
[d _i]	= mm	(Pipe Internal Diameter / 管子内径)
[v]	= mm ² /sec (= cSt)	(Kinetic Viscosity / 运动粘度)
[v]	= m/sec	(Flow Velocity / 流速)

The type of Flow change from Laminar to Turbulent when $Re_n > 2300$. This phenomena is used when Flushing hydraulic pipes, i.e. $Re_n = 3000$ is a minimum value when calculating least necessary flushing Flow.

当雷诺数 $Re_n > 2300$ 时液体将从层流状态转变为紊流状态，液压管系的投油正是利用了这一现象，而雷诺数 $Re_n = 3000$ 正是通过计算后得出的投油所需达到的最小值。

At the end of this document is a table where the minimum required Flushing Flow (Q = Re 3000) can be seen, inputs are Pipe Internal Diameter (d_i), Kinetic Viscosity (?). In this table you will also find Pressure Drop/10m Pipe (?p/10m) and Flow velocity (v).

文件的最后附有一个表格，它提供了不同管子内径 (d_i)、不同运动粘度 (?) 下所需要的最小投油流量 (雷诺数 Re3000 时)。同时，也可以知道每 10 米管子所产生的压力损失 (?p/10m) 和流速 (v)。

Kinetic Viscosity, i.e. ISO VG, changes about logarithmically with temperature, so a Viscosity – Temperature – Diagram must be available for the used hydraulic flushing oil in order to put in the correct Viscosity – value in a.m. table. A typical example diagram can be seen at the end of this document.

运动粘度，例如采用 ISO VG 标准，将根据不同的温度按对数关系变化，为了投油时在前一个表格中选取正确的粘度值，运动粘度-温度关系图表是必须的。

6. FLUSHING PREOCEDURE

投油过程

- 6.1 Fill the system by feeding the flushing fluid to the flushing rig so that the fluid is filtered before entering the system. New fluid is not allowed to fill in the system without filtered through a sufficient filter.
通过投油设备向管系中注油，注意油液在进入管系前必须通过滤器。新油禁止不通过滤器直接注入系统。
- 6.2 Circulate the flushing fluid and bleed the system to remove trapped air. Heating the fluid to a temperature as described in para 5.1.
使清洗油循环流动。同时进行系统放气，排除混在系统中的空气。清洗油应按要求加热到一定的温度（见 5.1）。
- 6.3 Pressure pulse accelerator or vibrations (hammering) to pipe can shorten the flushing time.
使用脉冲压力加速器或者震动（用小木锤）液压管能够缩短投油时间。
- 6.4 Change the inlet and outlet of flushing rig to make flow direction reverse, repeat loop flushing. Check filter contamination by inspection of the filter indicator regularly during flushing. Normally flushing time should be more than 12 hours, and after flushing rig running half an hour there is no contamination found in filter by means of visual. Oil contamination status to be regularly checked during the flushing period by use of particle counter. Alternative is, a fluid oil contamination laboratory test. By using a on line particle counter the flushing time can be optimal.
变换清洗系统的进、出油口，使得清洗油反向流动，重复循环进行清洗。在投油过程中定期检查/处理滤器污染状况。一般情况下，每个回路最少需要投油十二个小时，且必须保证系统运转半个小时后，滤器中目测不到污染物存在。最后使用颗粒检测仪在投油进行检查或者进行试验室化验来确定油液的清洁度。投油时直接在现场使用颗粒检测仪检验效果最佳。
- 6.5 If the system comprises of several loops, change the flushing rig connection to another loop and repeat the above procedure.
如果系统由多个回路组成，请将投油设备与其它回路连接后重复上述过程。
- 6.6 When the system has attained the required degree of cleanliness drain the system, disconnect the flushing rig and remove the bypass pipes. Examine the exposed openings and if any section is found unsatisfactory it should be removed for separate cleaning or replaced, the flushing procedure should then be repeated.
当管系的清洁度达到要求的等级后请排除管路中所有的油液，拆除与投油设备的连接和临时跨接管。检查暴露部分的管件，如果某一段发现不理想请拆除进行单独清洗或更换，投油过程将重新进行。
- 6.7 Complete the assembly of the system by fitting the pumps, cylinders, filter elements and any valves that were bypassed. Fill up the system with pre-filtered hydraulic oil with correct Viscosity (ISO VG) and as high as possible Viscosity Index (V.I.), repeat

the flushing procedure using the system pumps, venting the system to remove trapped air, with special attention being paid to dead-ends.

将未参加投油的泵、油缸、过滤器和阀件连接完毕。向系统中注入已经过滤的正确粘度的液压油（ISO VG），用系统泵组重复投油过程，排除残留在系统中的空气，尤其请注意管路中的死角。

- 6.8 Operate all valves so that the actuators move through their full travel and continue this procedure for the whole system. Check that the filter clogging indicator indicates OK. Take fluid particle count samples and check that the required degree of cleanliness has been attained.

操纵阀件，让整个系统中的执行组件来回做满行程的运动。检查所有滤器的报警指示灯工作正常。取样油液进行颗粒检测，证实所要求的清洁度已经达到。

7. Contamination In service

调试过程中的污染

- 7.1 For fresh water contamination, the operation of a purifier is usually sufficient to remove contaminants.

淡水污染，常使用净化器排除污染。

- 7.2 In case of severe sea water contamination or contamination with harmful foreign material, it will be necessary to remove the operating oil and clean and flush the system.

如果是海水或者有害杂质污染，请排除液压油，清洁并对管系投油。

- 7.3 In case of minor contamination applicable portions of the flushing procedure, should be followed.

如果是投油过程产生的二次污染，请继续投油。

- 7.4 In case of severe contamination – not including sea water – the whole of the flushing procedure should be followed. Modifications of flushing time and circulating temperatures should be made depending upon the circumstances of the contamination.

如果是调试过程中的污染，不包括海水污染，应该继续投油过程。投油时间和循环温度的调整必须根据污染程度确定。

- 7.5 Sea water contamination requires a very special procedure for handling. After removal of excess salt water, corrosion inhibitors specifically developed for this type of contamination must be used in the system. Careful cleaning procedures must be followed to obtain a satisfactory condition in the hydraulic system. Following this, the full flushing procedure should be followed.

海水污染需要特殊的处理。在排除有盐分的水后，必须在系统中使用特殊的腐蚀抑制剂。为了使液压系统达到理想的状态需要仔细清洁，此外，应该继续进行投油。



STANDARD
HYDRAULIC SYSTEM
Guidelines for flushing

Document: HQG.09.1000
Catalogue group: Guidelines
Rev: A
Editor: Tony Zhou
Approved: Guo Wei

Necessary Flushing Flow as per Pipe Internal Ø to reach Re = 3000

不同管子内径下达到雷诺数 Re = 3000 时所需的投油流量

Pipe Internal Ø _{di} (mm)	Flow Q (l/min)	Kinetic Viscosity ν (mm ² /s=cSt)	Reynolds Number Re _n (n)	Flow Velocity v (m/s)	Pressure Drop / 10m Pipe $\Delta p/10m$ (Bar/10m)
8	11,3	10	3 000	3,75	3,35
8	17,0	15	3 000	5,63	7,54
8	22,6	20	3 000	7,50	13,40
8	28,3	25	3 000	9,38	20,93
8	33,9	30	3 000	11,25	30,14
8	39,6	35	3 000	13,13	41,02
12	17,0	10	3 000	2,50	0,99
12	25,4	15	3 000	3,75	2,23
12	33,9	20	3 000	5,00	3,97
12	42,4	25	3 000	6,25	6,20
12	50,9	30	3 000	7,50	8,93
12	59,4	35	3 000	8,75	12,16
16	22,6	10	3 000	1,88	0,42
16	33,9	15	3 000	2,81	0,94
16	45,2	20	3 000	3,75	1,67
16	56,5	25	3 000	4,69	2,62
16	67,9	30	3 000	5,63	3,77
16	79,2	35	3 000	6,56	5,13
20	28,3	10	3 000	1,50	0,21
20	42,4	15	3 000	2,25	0,48
20	56,5	20	3 000	3,00	0,86
20	70,7	25	3 000	3,75	1,34
20	84,8	30	3 000	4,50	1,93
20	99,0	35	3 000	5,25	2,63
24	33,9	10	3 000	1,25	0,12
24	50,9	15	3 000	1,88	0,28
24	67,9	20	3 000	2,50	0,50
24	84,8	25	3 000	3,13	0,78
24	101,8	30	3 000	3,75	1,12
24	118,8	35	3 000	4,38	1,52
30	42,4	10	3 000	1,00	0,06
30	63,6	15	3 000	1,50	0,14
30	84,8	20	3 000	2,00	0,25
30	106,0	25	3 000	2,50	0,40
30	127,2	30	3 000	3,00	0,57
30	148,4	35	3 000	3,50	0,78
40	56,5	10	3 000	0,75	0,03
40	84,8	15	3 000	1,13	0,06
40	113,1	20	3 000	1,50	0,11

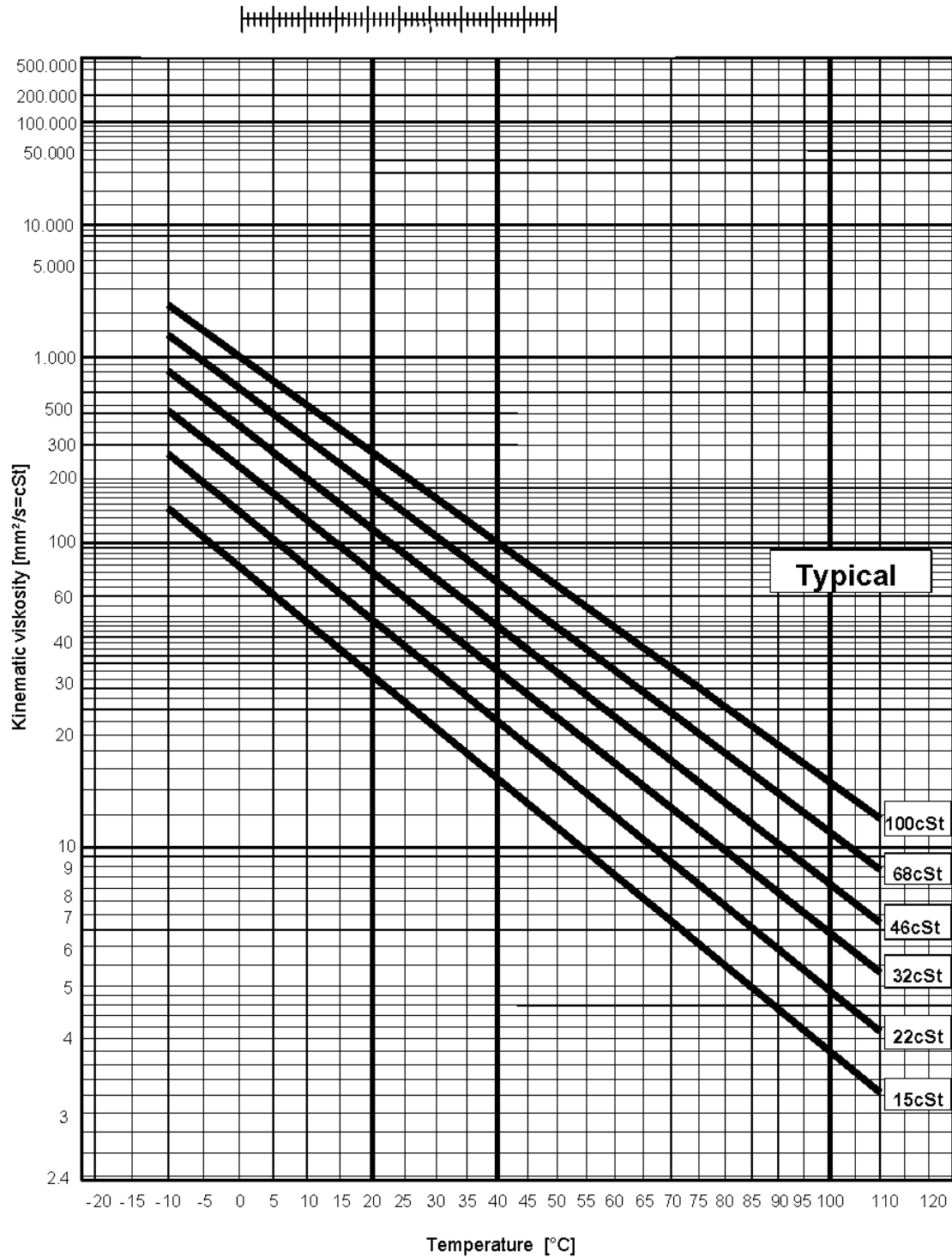


STANDARD
HYDRAULIC SYSTEM
Guidelines for flushing

Document: HQG.09.1000
Catalogue group: Guidelines
Rev: A
Editor: Tony Zhou
Approved: Guo Wei

Pipe Internal Ø di (mm)	Flow Q (l/min)	Kinetic Viscosity ν (mm ² /s=cSt)	Reynolds Number Re _n (n)	Flow Velocity v (m/s)	Pressure Drop / 10m Pipe $\Delta p/10m$ (Bar/10m)
40	141,4	25	3 000	1,88	0,17
40	169,6	30	3 000	2,25	0,24
40	197,9	35	3 000	2,63	0,33
50	70,7	10	3 000	0,60	0,01
50	106,0	15	3 000	0,90	0,03
50	141,4	20	3 000	1,20	0,05
50	176,7	25	3 000	1,50	0,09
50	212,1	30	3 000	1,80	0,12
50	247,4	35	3 000	2,10	0,17

Viscosity - Temperature - Diagram





BSI/ISO CLEANNESS CLASS

BSI/ISO 清洁度标准

Range of impurity 杂质颗粒数范围		Class 等级
Min. quantity of grain 最少颗粒数	Max. quantity of grain 最多颗粒数	
8×10^6	18×10^6	24
4×10^6	8×10^6	23
2×10^6	4×10^6	22
1×10^6	2×10^6	21
500×10^3	1×10^6	20
250×10^3	500×10^3	19
130×10^3	250×10^3	18
64×10^3	130×10^3	17
32×10^3	64×10^3	16
16×10^3	32×10^3	15
8×10^3	16×10^3	14
4×10^3	8×10^3	13
2×10^3	4×10^3	12
1×10^3	2×10^3	11
500	1×10^3	10
250	500	9
130	250	8
64	130	7
32	64	6
16	32	5
8	16	4
4	8	3
2	4	2
1	2	1

NOTE:

1. The list shows the quantity of grain in 100ml sampling oil.
2. The cleanliness class consists double number, the first number means the quantity of grain bigger than 5 micro in 100ml sampling oil, and the second number means the quantity of grain bigger than 15 micro in 100ml.

注:

1. 表中所列为 100 毫升取样油中颗粒数
2. 清洁度代号由两个分类号组成, 第一个分类号表示在 100 毫升取样油中大于 5 微米的颗粒数, 第二个分类号表示在 100 毫升取样油中大于 15 微米的粒子数。



STANDARD
HYDRAULIC SYSTEM
Guidelines for flushing

--

Document: HQG.09.1000
Catalogue group: Guidelines
Rev: A
Editor: Tony Zhou
Approved: Guo Wei

Contrast list between difference cleanness standard and BSI/ISO

常用清洁度等级标准与 BSI/ISO 对照表

BS 5540/4 ISO/DIS 4406	DEF STD 05/42		NAS 1638 CLASS	SAE 749 CLASS
	TABLE 1	TABLE 2		
11/8	-	-	2	-
12/9	-	-	3	0
13/10	-	-	4	1
14/9	-	400F	-	-
15/9	400	-	-	-
15/10	-	800F	-	-
15/12	-	-	6	3
16/10	800	-	-	-
16/11	-	1300F	-	-
16/13	-	-	7	-
17/12	1300	2000F	-	-
17/14	-	-	8	5
18/12	2000	-	-	-
18/13	-	4400F	-	-
18/15	-	-	9	6
19/13	4400	6300F	-	-
19/16	-	-	10	-
20/13	6300	-	-	-
20/17	-	-	11	-
21/14	15000	-	-	-
21/18	-	-	12	-
22/15	21000	-	-	-
23/17	100000	-	-	-