ifm
industrial fluid management

High Velocity Oil Flushing Guide

F OHGH presented
in partnership with Noria Corporation

High velocity oil flushing (HVOF) is the process of cleaning pipes, tubing, and other system components by forcing oil through the system at turbulent flow rates. This process removes contamination particles, old oil, rust, and other particles that build up on the walls of pipes.

PROBLEMS WITH PARTICLES

The exclusion and removal of contamination are among the most significant factors of machine health. Uncontrolled contamination in a machine's lubrication system can lead to catastrophic failures and create operational inefficiencies. Periodic deep cleanings of machine assets are necessary to mitigate or avoid these problems.

Turbine oil may degrade or darken for a variety of reasons, but contamination is a common culprit. If oil analysis tests identify contamination problems, it may be time to consider a high velocity oil flush.

Filtration, and the use of contamination exclusion products like desiccant breathers, are an important line of defense against contamination, but particles will still build up over time. Contaminant particles and other factors contribute to oil degradation, causing deposits of sludge and varnish to accumulate on machine surfaces. Even a brand-new system is often filled with debris from the manufacturing process, which could lead to early failure if it is not removed during commissioning. Flushing can help mitigate these problems and restore oil systems to a state of cleanliness that slows oil degradation, reduces varnish formation, extends machine life, and improves reliability.

TYPES OF OIL FLUSHES

Flushing a lubricant system can take on many forms. Some flushing methods that are less intensive (and usually less potent) than high velocity oil flushing. These methods can be performed with simpler equipment, but do not produce the same level of cleanliness achieved by HVOF.

Circulation Filtration

Also known simply as an oil flush, this process involves external filtration circulating on the reservoir and can be performed while the system is in operation and the system pumps are functioning normally. This type of flush is best suited to limited-scope annual cleaning, filter changes, or lubricant changes (using the same type of lubricant). Field kits or laboratory analysis should be used to determine particle count following a circulation filtration procedure.

> "Critical systems should be submitted to a high velocity oil flush every five years, and non-critical systems should have a flush performed every ten years."

Rinse/Purge

Often used when filling a system with a neutral fluid or a new charge of oil. The rinse/purge method involves draining the system, adding the flushing fluid to the reservoir's minimum circulation level, and circulating the fluid in a normal flow path using the system's pumps. This method is typically used during a lubricant change or conversion or to remove leftover detergents and cleaners.

System Flush

This method employs jumpers to bypass critical components and is used for light maintenance work. A system flush procedure uses the system's pumps to flush out foreign material and takes longer than a procedure that uses an external pump. Because it uses onboard pumps, this method is unlikely to achieve the flow rates needed to create turbulence.

Selecting the Best Type of Flush for Your Issue

When choosing a flushing type or tactics, it's important to align your conditions and goals with the most effective options available to you. IFM offers a range of options to our clients that include flushing, chemical cleaning, varnish removal and more. We bring the right combination of methods and tactics along with the expertise needed to deliver results.

Flush Zone (s) / Condition (s)	Drawdown filtration /separation	High turbulence, high fluid velocity, low oil viscosity	High flush oil temperature	Cycling flush oil temperature	Pulsating flush oil flow	Reverse flush oil flow	Wand flush tool	Charged particle technology	Solvent/detergent flush fluid	Checmical Cleaning	Mechanical Cleaning
Suspended contaminants or degradation products	U	U	S	N	S	U	S	U	R	N	N
Bottom sediment and water	S	U	S	N	S	U	U	N	R	R	N
Soft and loose surface deposits	R	U	U	N	U	U	U	S	U	U	N
Sticky, adherent surface deposits	R	S	S	N	S	S	S	S	U	U	U
Hard, crusty surface deposits	N	N	R	S	S	S	S	N	R	U	U
Hard, enamel-like surface deposits	N	N	N	N	N	N	N	R	R	U	U

U = Usually Effective S = Sometimes Effective R = Rarely Effective N = Not Effective or Practical

WHEN AND WHY TO PERFORM A HIGH VELOCITY OIL FLUSH

Pre-commissioning

Contaminants like metal shavings, weld spatter, and grinding debris are created and left behind during the fabrication and installation of certain machine systems and components. The removal of these contaminants prior to start-up is vital to protect the machine's internal components. A high velocity oil flush performed before a machine is commissioned ensures that these particles are eliminated.

Pre-commissioning is the most important time to perform a high velocity oil flush and is commonly overlooked.

Recommissioning

Laid-up equipment may have low-lying contaminants which are disturbed and mobilized when a machine is recommissioned. This can accelerate wear of gears, bearings, pumps, valves, etc.

Case Study: Gas Turbine Pre-Commission HVOF

IFM's work with the Noranda Alumina Refinery is one example of a successful high velocity oil flush as part of a pre-commissioning process. IFM was contracted for this project in advance of the commission and start-up of a gas turbine system. During the fabrication and installation of such a system, welding slag and metal shavings, dirt, water, and other contaminants accrue in the oil supply and return lines. Unless these materials are removed before the machine is activated, damage to internal components will ensue, and the ISO 4406 specification for fluid cleanliness will be difficult or impossible to maintain.

IFM technicians developed and implemented an HVOF procedure. Upon the installation of jumpers and flushing equipment, the technicians employed tactics like sparging, thermocycling, and the mechanical knocking of pipes. These techniques were implemented until clean screen test results appeared, which occurred within five days of mobilization. Following two clean screen test results, the machine's reservoir was emptied, and a confined space entry cleaning of the system's tank commenced, removing all gross contamination. Oil was then reintroduced to the machine and filtered until the ISO 4406 16/14/11 cleanliness code was satisfied.

Preventive Maintenance

High velocity oil flushing should be a regular part of lubrication routine maintenance. As a general rule, critical systems should be submitted to a high velocity oil flush every five years, and non-critical systems should have a flush performed every ten years. Employing HVOC procedures routinely can prevent problems from arising during a machine's lifetime.

Catastrophic Failure

When failure occurs with a critical component, particles and other contamination accumulate in the machine in areas like the lube oil piping. Once a repair has been made, or a component has been replaced, a high velocity oil flush removes these contaminants and ensures that the cleanliness of the pipes and tubes is restored.

Cooler Failure

When mixed with oil and additives, antifreeze (glycol) produces acids, sludge, deposits and precipitants. Oil flow restriction, plugged filters, corrosion, mechanical interference with machine movement, and impaired fluid properties can all result from coolant mixing with in-service oils.

Filter Failure

When a filter fails, it will release debris into an active system. This can lead to greatly accelerated wear unless a flush is performed.

Part Changes or Major Repairs

Like the machine itself, the machine's components retain contaminants from their fabrication process. Performing a high velocity oil flush when changing or upgrading parts ensures no new contamination is ingressed.

After Wrong Lubricants are Mixed

Mixed lubricants can create insoluble by-products from the reactions of incompatible base oils and additives. For instance, polyglycols, when mixed with mineral oils, produce a thick, pasty sludge.

An oil filter from a gas turbine system plugged with sludge. Regular high velocity oil flushing can help keep varnish and sludge under control, but if a filter has already plugged or failed, a high-velocity oil flush may be needed to remove all the debris released into the oil system.

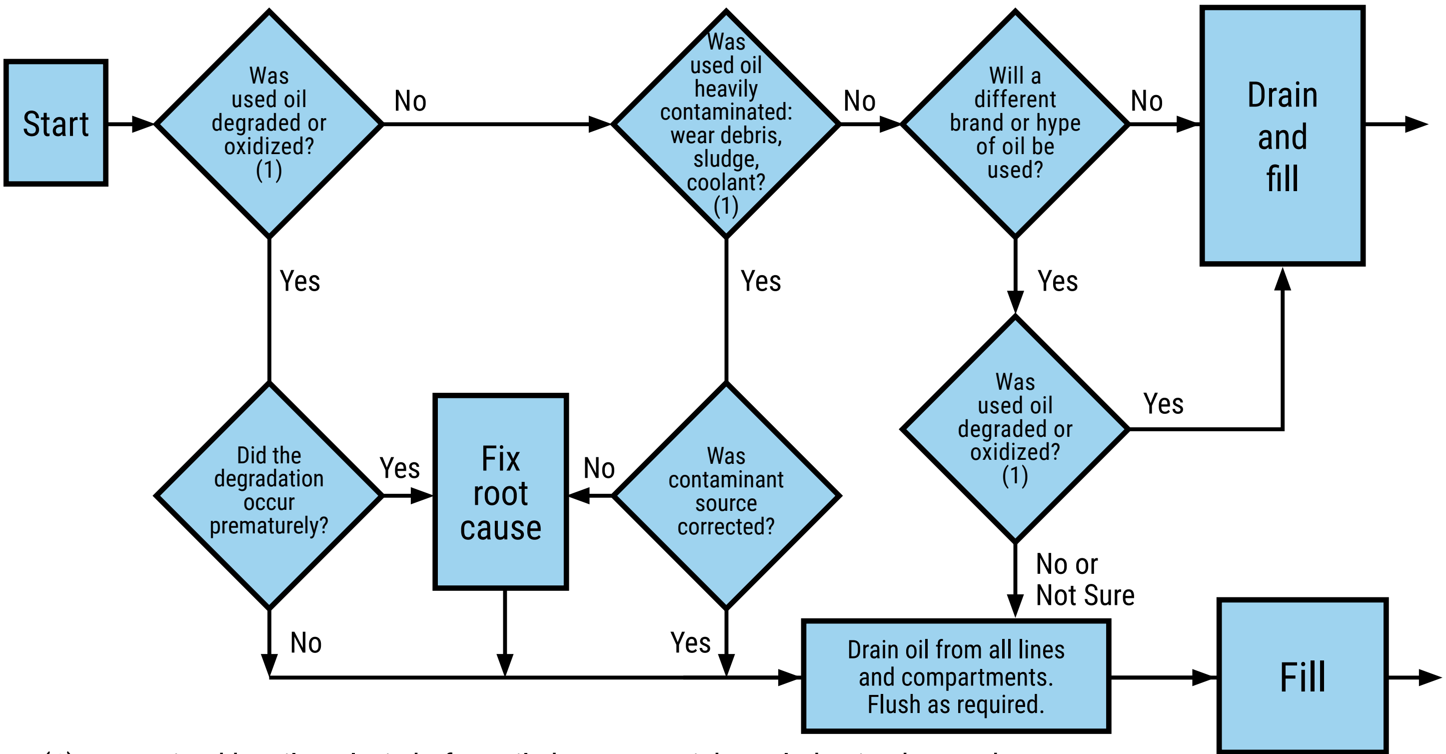
Oil Conversion

Shifting to a different lubricant oil introduces the risk of compatibility issues with the old oil. A high velocity oil flush removes all traces of the previous lubricant (and any existing wear particles). A small amount of the new lubricant (deemed "sacrificial" oil) is typically used to irradicate any remnants and residue from the old oil.

Case Study: Lock and Dam Gear Box Flush

The Army Corps of Engineers contracted IFM to flush gear boxes, 69 in total, for three dams along the Mississippi River. The configurations of the locks and dams, along with the high water levels, presented unique challenges. A crane barge was used to transport and place the flushing equipment at the top of each dam. When the equipment was situated, IFM technicians introduced the flushing compound to each gear box, and each box underwent a 24-hour flushing cycle. After the cycle, the flushing compound was drained, and each gear box was refilled with new oil. Additionally, each gear box was inspected to ensure structural integrity and to find any potential mechanical defects.

The success of IFM's work on this project allows the Army Corps of Engineers to maintain the desired water level, increasing the safety of people living along the river. After the project was complete, the Army Corps of Engineers' Contracting Officer's Representative delivered a performance review letter, rating IFM's quality, scheduling, cost control, management, regulation compliance, and safety as "excellent," and praising the entire crew's efforts.



(1) Determined by oil analysis before oil change, varnish or sludge is observed
(2) Determined by suitable ASTM test protocol

This flow chart can help you determine when a drain and fill procedure is needed or when the situation calls for a complete oil flush.

HOW HIGH VELOCITY OIL FLUSHING WORKS

The ultimate goal of high velocity oil flushing is removing particles and other contaminants (like old oil) from the walls and crevices of piping and tubing. This goal is achieved by creating a highly turbulent oil flow within the pipes. Under typical operating conditions, the oil flowing through a machine's pipes moves in a laminar flow.

By inducing a turbulent flow, a high velocity oil flushing operation dislodges contaminants that have formed over time on the walls of pipes and tubing. Once dislodged, these contaminants are carried downstream by the flowing oil and removed by filtration elements.

While any oil flow with a Reynolds Number above 4000 is considered turbulent, high velocity oil flushing procedures generally aim to reach a Reynolds Number of 8000 or higher. In order to achieve a higher Reynolds Number, the oil used for a high velocity oil flush is typically heated to a temperature of 150-170 degrees Fahrenheit (65-76 degrees Celsius); doing so decreases the oil's viscosity, allowing for a more turbulent flow.

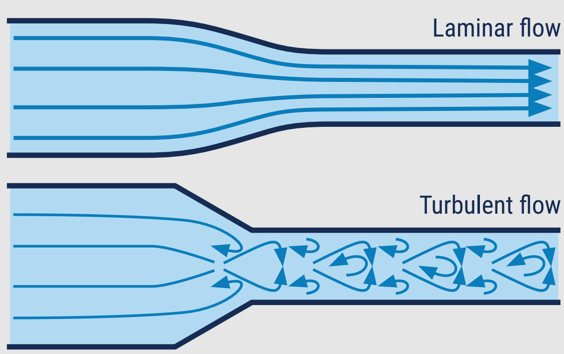
TYPES OF FLOW & REYNOLDS NUMBER

Laminar Flow — The fluid moves smoothly. The layers of fluid particles move past one another without much mixing.

Turbulent Flow — The fluid moves chaotically. The fluid particles change directions frequently due to altering pressures and flow velocities, causing mixing.

The Reynolds Number is used to determine how a fluid is flowing and to predict flow patterns. A low Reynolds number (< 2000) typically denotes a laminar flow, while a high Reynolds Number (> 4000) is indicative of a turbulent flow. The area between 2000 and 4000 is referred to as transitional flow and is marked by instability and the onset of turbulence. Factors such as velocity, viscosity, and the roughness of piping influence turbulence.

Laminar and Turbulent Flow



CLEANLINESS STANDARDS

The cleanliness standards required for machines are typically set by the OEM. There are two major reference standards, ISO 4406 and NAS 1638.

ISO 4406

A method for standardizing the way in which particle count data is reported, allowing for a rating of oil cleanliness to be presented as such: A/B/C. In this rating, the integer in the A position represents (in parts per milliliter, or p) the concentration of particles with a diameter of 4 µm (microns) or larger, the B position represents particles with a diameter of 6 µm or larger, and C, a diameter of 14 µm or larger. A rating of 16/14/12, for example, would mean that a lubricant contains between 320 and 640 p/ml of 4 µm or larger particles, between 80 and 160 p/ml of 6 µm or larger particles, and between 20 and 40 p/ml of 14 µm or larger particles.

NAS 1638

A National Aerospace Standard is used to communicate particle count data. Although this standard is considered obsolete, it is still commonly used in the industry.

Reynolds Number Defined

$$\textbf{Re} = \frac{21{,}200}{v \times d}$$

Where:
Q = Flow Rate (L per minute)
v = oil viscosity at flush temperature (cSt)
d = inside pipe diameter (mm)

Re < 2300 — Laminar Flow
2300 < Re < 4000 — Transition
Re > 4000 — Turbulent Flow

Need to Check a Calculation?

Use our simple Reynolds Number Calculator to determine if the High Velocity Oil Flush you're planning will achieve turbulent flow.

IFM High Velocity Flushing Process

More Than	Up To and Including	ISO Code
(p/ml)	(p/ml)	
80,000	160,000	24
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2,500	5,000	19
1,300	2,500	18
640	1,300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8

ISO Code ratings for Lubricant Cleanliness

Flush Design & Flow Path Engineering

Mechanical Engineers design a flow path, working with the project team to create the most effective approach. The engineers consider every aspect of each machine, ensuring that no part of the unit is left unclean. The required Reynolds Number is considered, and the selection of an appropriately sized flushing machine maximizes the effectiveness of the flushing process.

Pipefitting & Jumper Installation

Before the flushing equipment is installed, jumpers are put in place, and the machine components that are not being submitted to the flush are removed, manually cleaned, and tagged. These components are reinstalled after the flushing process is complete.

Pre-Startup Leak & Pressure Test

Before the circulation phase of the oil flush begins, a visual inspection of the entire project will be performed. This inspection, performed by IFM technicians and customer representatives, is intended to ensure that no leaks are present and to determine if the system is ready for the oil flush.

High Velocity Oil Flush

Once the initial steps are reviewed, the HVOC plan is set in motion. IFM technicians perform the high velocity oil flush using IFM's proprietary flushing technologies and, depending on the customer needs, may also employ techniques such as:

- Heat/Cool Cycles
- Active Purging Strategy
- Mechanically Knocking Piping
- Reverse Flow Manifolds

The techniques used during the course of the high velocity oil flush will be agreed upon while writing the process procedures before the flush begins.

What are Jumpers?

Jumpers are short hose sections (typically fabricated for a specific job) used to bypass sensitive components in a hydraulic or lube oil circuit. Components like pumps and valves must be bypassed in order to avoid damage from increased pressure and to reduce flow restriction.

Confined Space Console Cleaning & Inspection

If required, the inside of the console is cleaned through a confined-space entry procedure. During this process, the reservoir's internal walls and components are cleaned with wet-vacs, scrapers, squeegees, and lint-free rags. The reservoir and its components, like gaskets and suction strainers, are then inspected for indications of potential leaks or ingression areas. A set of before-and-after photos of this process is included in the final job report.

Verification of Pipe & Oil Cleanliness

During the planning phase of the high velocity oil flush project, the customer or the Original Equipment Manufacturer (OEM) will establish the ISO 4406 or NAS 1638 cleanliness requirements. Pipe cleanliness is verified by a visual inspection of mesh screens, and oil cleanliness is verified by a patch test.

Post Job Reporting & Documentation

During the course of the project, client project managers will receive a nightly email containing the status of the project as well as pictures, budgetary updates, and daily goals. Within 30 days of project completion, a comprehensive post-job report will also be available.

Case Study: Fertilizer Plant Varnish Removal

IFM was contacted for assistance with a thrust-bearing temperature issue being experienced at a CF Industries fertilizer plant. The high temperatures of the thrust-bearings had caused a total of six days of plant downtime. IFM technicians discovered the cause of the issue — varnish build-up on the bearings — and were able to solve the problem without shutting down the plant's compressor train.

IFM was able to eradicate the varnish by partially draining the oil and adding a proprietary varnish mitigation chemical. This chemical removed the varnish from the pipe walls and bearings, and the oil remaining in the system carried the removed varnish to the oil reservoir, where it was then removed by means of filtration. The project was completed in two days, and the bearing temperatures were reduced from 277 degrees Fahrenheit to under 200 degrees Fahrenheit.

About Industrial Fluid Management

Industrial Fluid Management (IFM), a division of Gaubert Oil Company, specializes in lubrication related products and services for the industrial, marine, oil & gas, petrochemical, and refining markets. IFM leverages over 95 years in the lubrication industry to offer lubrication solutions with an unmatched level of expertise, safety, and quality.

IFM is committed to excellence and innovation. We work with reliability and maintenance professionals to increase reliability through quality lubrication.

Our Parent Company

Founded in 1926, Gaubert Oil Company has been providing quality fuel, lubricants, chemicals, equipment, and lubrication-related services to North America's largest industries for decades. Gaubert Oil Company provides safe, accurate, and reliable delivery services throughout the Southeastern United States. At Gaubert Oil Company we're proud of our reputation for excellence and our continued commitment to being First in Service.

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