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USACE / NAVFAC / AFCEC **UFGS-48 06 15 (November 2023)**

Preparing Activity: USACE **Superseding**
UFGS-48 06 15 (August 2020)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2025
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DIVISION 48 - ELECTRICAL POWER GENERATION

SECTION 48 06 15

TURBINE OIL

11/23

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SECTION 48 06 15

TURBINE OIL
11/23

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NOTE: This guide specification covers the requirements for turbine oil for hydroelectric power plants. Requirements in this section assume a complete or significant change out of power plant oil. For contracts procuring smaller amounts of supplemental oil, testing requirements may be lessened depending on risk-tolerance, and it might be cost-effective for all testing to be performed by the Government rather than the Contractor.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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NOTE: It is advised to consult with the technical proponent of the specification prior to its use. Corps Districts/Project offices can contact the Hydroelectric Design Center for assistance and/or request additional information/clarification related to the information contained in the entire document (POC: Catherine Campbell 503-808-4255 or Catherine.L.Campbell@usace.army.mil).

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PART 1 GENERAL

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NOTE: Initial compatibility testing is more involved than per-delivery compatibility testing. Initial compatibility testing is to demonstrate that the chemistry of the new name-brand oil is itself compatible specifically with the in-service oil at the plant in question. Per-delivery compatibility testing is to confirm the delivered oil is in fact the correct oil, and to confirm that no contamination occurred during delivery which affected compatibility. Often the initial compatibility testing is performed by the Government, for instance using oil samples which are sent in together with bids for a job. For a very large job such as a major powerhouse rehabilitation, where the turbine oil replacement is only a fraction of the cost, it might be advantageous to require the Contractor to perform the initial compatability testing. Initial compatibility testing should include all Tier 1 and Tier 2 tests in ASTM D7155 "Standard Practice for Evaluating Compatibility of Mixtures of Turbine Oil" plus Viscosity and Acid Number from Tier 3, and RPVOT, Rust Prevention, and Copper Corrosion from Tier 4. This testing should be performed even if the oil being purchased for the complete plant oil replacement is the same name-brand of oil which was purchased for the previous complete plant oil replacement, to ensure that even the same name-brand oil is still compatible with in-service oil. (A name brand can have a change in the proprietary recipe without notification to the Government.) Depending on the situation, an additional Tier 4 test may be recommended also to reduce risk, the Sludging and Corrosion test. This test is onerous, especially if performed on 5 or 6 samples with varying ratios of new and old oil, because it takes 1,000 hours just to run the test. An example scenario when the Sludging and Corrosion test may be warranted is when turbine oils from different manufacturers are being mixed (because neither manufacturer can fully vouch for expected compatibility between their oils), and in particular when the new oil will NOT be completely replacing the old oil, meaning the oils must work together long-term, in any ratio, because the Plant's turbine oil all gets mixed together over the years. Initial test results can take up to 4-6 weeks even expedited (and will take even longer if 1,000-hr tests are ordered). If multiple bids/brands might be accepted, testing on bidder-submitted samples by the Government may exceed GPC (Government purchase card) limits depending on number of samples/bids. If testing is to be done at this stage, it is recommended to solicit quotes ahead of time to allow for timely testing and adequate competition. The testing

duration should also be taken into account when soliciting the contract.

Note that for significant quantities of oil, such as a railcar at at time (20,000-24,000 gallons), and especially if the Contractor is filtering the oil pre-delivery, the lead time between placing a task order and getting a delivery can be 12-16 weeks or longer.

This specification assumes use of traditional Group 1 and 2 mineral oils, not any Environmentally Acceptable Lubricants (EALs), because a drop-in EAL turbine oil replacement is not considered technically feasible at this time. If experimenting with a synthetic EAL is desired, for instance during a major rehabilitation in an environmentally sensitive area, replacing turbines, and with opportunity to replace any incompatible oil-wetted materials (seals, paint), please contact the PROPONENT. There are efforts both pending and underway to develop, research, test, and vet potentially feasible EALs, for example by the Centre for Energy Advancement through Technological Innovation (CEATI) Hydropower Plant Equipment Interest Group (HPEIG). At this time, however, the most viable candidates for performance in hydropower units are also entirely incompatible with in-service oils, as well as incompatible with several materials. Additionally, there is concern that EALs might not have as much hydrodynamic thrust bearing load capacity as traditional mineral oils.

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NOTE: The 17/15/12 cleanliness level and 100 ppm water content PPM level in this spec assume that all the oil is being changed in a Powerhouse at once, in which case it is typically more convenient for the Government to have the Contractor perform filtration and dehydration such that new oil does not require any purification by the Project prior to use. (For digital governors, the offline "kidney-loop" filter dedicated to the governor sump can further polish the governor oil up to 15/13/10, if the governor sump has breathers to exclude contamination from the air.) If only supplemental oil is needed or the Project wishes to handle purifying, the cleanliness and water requirements should be changed to FIO or removed.

Two recommended ways of oil procurement are through a SATOC (Single Award Task Order Contract) or a DLA (Defense Logistics Agency) purchase. A SATOC allows for issuing task orders each time the powerhouse is ready to accept another "batch" of oil. DLA purchases allow for specification of a name brand product for consistency and risk reduction. Extra storage may be key to having enough flexibility to

deliver only the new oil from the clean lubrication oil tank in the oil storage room to the powerhouse for makeup oil and to fill empty units, while holding all oil that is drained back to the dirty lubrication oil tank in the oil storage room to be trucked away. During this transition, the Project's own lube oil purifier would be entirely idle, with no oil being moved from the dirty tank to the clean tank. This offers tremendous savings and simplicity over constructing a parallel oil delivery system to keep the new and old oils separate. To get extra storage room for incoming and outgoing oil, it may be beneficial to empty out the transformer oil tanks, wasting any residual oil, testing for PCBs (hopefully none) and wiping those tanks down to accept lube oil, at least temporarily. At the end of the contract, it may be desirable to empty and wipe down at least the dirty transformer oil storage tank again, to be ready in case a sudden urgent need to drain a transformer comes up. To change all the oil in the powerhouse this way, it is strongly recommended for the new oil being delivered to be clean enough to go straight to the units.

Ordering "batches" of oil in railcar quantities (20-24k gallons) to the extent possible will get the Government a better price.

Oil can be delivered to temporary Contractor-provided storage containers onsite at the Project, or the delivery truck's tanks can remain on-site within a containment berm. This allows the Government to use a sample taken from the actual delivered oil, send it to the lab for testing, and only move it into Government tanks or equipment after it passes all tests. If the oil is immediately moved into Government tanks or equipment, and failed oil test results arrive later, this can be very difficult to resolve satisfactorily with the Contractor. (The risk may be acceptable in a case where a Contractor is making multiple oil deliveries, and has successfully delivered acceptable oil a few times, and is using the exact same procedures through the contract.)

For change out of all the oil in a Powerhouse, it is highly recommended to flush the system first; see EM 1110-2-1424 LUBRICANTS AND HYDRAULIC FLUIDS. Contact the Hydroelectric Design Center for questions, concerns, and support for flushing specifications.

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1.1 SUMMARY

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NOTE: When changing the oil in a Powerhouse, there will typically be some waste. It is highly desirable to have flexibility in the contract to allow the

last delivery order to be an unknown amount smaller than a full truckload, though typically that will mean a higher per-gallon price for the final delivery.

It is desirable to have zinc-free turbine oil. Zinc-free oil is more environmentally friendly. Also zinc additives like "ZDDP", while effective, can break down under certain conditions into undesirable compounds. Over time, ZDDP + Water + Heat => Sulfuric Acid + Hydrogen Sulfide. This can pose a risk, for example in a poorly ventilated area such as the bottom of a damp regulating outlet tower in a reservoir with hydraulic-operated gates and a submerged oil heater in the sump. Typically for hydropower applications, zinc or ZDDP as an anti-wear additive is not needed due to relatively mild conditions, though there are some exceptions such as when speed-increasing gears are part of the equipment being lubricated by the same turbine oil. (Even in these cases, "extreme pressure" additives should be avoided due to being more chemically aggressive and unnecessary.) Note that some oils may have "EP" in the name brand without actually having the aggressive additives.

For turbine bearings and governors in powerhouses, however, compatibility requirements have sometimes led to the choice of non-zinc-free oils.

Typically if an oil is zinc-free, its Product Data Sheet (PDS) will explicitly claim "zinc-free".

There are times when a particular name brand of oil is justified and this is known prior to advertisement because comprehensive compatibility checks were done beforehand for a complete oil replacement, or the quantity of top-off oil does not justify experimenting with anything other than the existing name brand. This specification has bracketed choices which allow for a name brand to be indicated if approved.

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NOTE: Depending on initial oil compatibility testing strategy and/or whether a name brand is justified, consult with contracting regarding whether the language about "...bidders must submit one gallon of proposed turbine oil with proposals" in the second paragraph belongs here and/or in Instructions to Offerors.

The seven ratios below include 2 special ratios (highlighted orange) using 5% and 95%. These are not normally part of the ASTM D7155 testing, but can be included for an extra fee if communicated with the oil testing lab ahead of time. The number of ratios can be reduced depending on the situation and

risk tolerance. The test with just 5% in-service oil is meant to represent a situation where all of the in-service oil is intended to be removed, but some residue remains. The test with just 5% new oil is meant to represent a situation where a small portion of new oil is used as "make-up" oil in governor sump full of in-service oil.

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This specification includes [zinc and]chlorine-free rust and oxidation inhibited (R&O) mineral oils for use in hydraulic turbine and generator bearings, Kaplan turbine hubs, hydraulic-turbine governors, and other applications, where high grade turbine oil having anti-corrosion and anti oxidation properties is required. In addition, this specification covers delivery and installation of up to [_____] gallons of approved [(ISO viscosity grade 68)][(ISO viscosity grade 100)] turbine oil for [_____] Powerhouse. Laboratory test results for [each railcar of oil ordered and for]each truck of oil delivered are required.[Oil is to be delivered at the unusual cleanliness level of 17/15/12(c) and with less than 100 ppm of water.]

[Because compatibility is a critical feature of replacement turbine oil, bidders must submit one gallon of proposed turbine oil with proposals. The Government will have compatibility tests performed at its own cost. Any oils which fail to demonstrate compatibility with the in-service oil at [_____] Powerhouse per ASTM D7155 will be ineligible. The following tests from ASTM D7155 will be performed:.

From Tier 1 Visual Appearance, all tests.
From Tier 2 Interfacial Properties, all tests.
From Tier 3 Physical/Chemical Properties, ASTM D445 or ASTM D7042, and ASTM D664 or ASTM D974.
From Tier 4 Performance Properties, ASTM D2272, ASTM D665 [, and ASTM D130][ASTM D130, and ASTM D4310].

The above tests will be performed with the following seven ratios:

100 percent new oil to 0 percent in-service oil
95 percent new oil to 5 percent in-service oil
90 percent new oil to 10 percent in-service oil
50 percent new oil to 50 percent in-service oil
10 percent new oil to 90 percent in-service oil
5 percent new oil to 95 percent in-service oil
0 percent new oil to 100 percent in-service oil

Potential bidders may wish to have their own tests conducted prior to bidding, and may request a one-gallon sample of in-service oil for that purpose.]

1.2 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. The year refers to the basic date of issuance of the standard or code. All Codes and Standards are to include published Interpretations and Interim Amendments or Revisions by the Standard or Code Authorities referenced must be current as of date of contract.

ASTM INTERNATIONAL (ASTM)

ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D130	(2018) Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
ASTM D445	(2019a) Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
ASTM D664	(2018; E 2018; E 2019) Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration
ASTM D665	(2019) Standard Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water
ASTM D892	(2013; E 2016) Standard Test Method for Foaming Characteristics of Lubricating Oils
ASTM D974	(2014; E 2016) Standard Test Method for Acid and Base Number by Color-Indicator Titration
ASTM D1401	(2019) Standard Test Method for Water Separability of Petroleum Oils and Synthetic Fluids
ASTM D2270	(2010; R 2016) Standard Practice for Calculating Viscosity Index from Kinematic

	Viscosity at 40 and 100°C
ASTM D2272	(2014a) Standard Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel
ASTM D3427	(2019) Standard Test Method for Air Release Properties of Petroleum Oils
ASTM D4057	(2012; R 2018) Standard Practice for Manual Sampling of Petroleum and Petroleum Products
ASTM D4177	(2016; E 2017) Standard Practice for Automatic Sampling of Petroleum and Petroleum Products
ASTM D4310	(2022) Standard Test Method for Determination of Sludging and Corrosion Tendencies of Inhibited Mineral Oils
ASTM D6304	(2016; E 2016) Standard Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
ASTM D7042	(2020) Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
ASTM D7155	(2011) Standard Practice for Evaluating Compatibility of Mixtures of Turbine Lubricating Oils
ASTM D7647	(2010; R 2018) Standard Test Method for Automatic Particle Counting of Lubricating and Hydraulic Fluids Using Dilution Techniques to Eliminate the Contribution of Water and Interfering Soft Particles by Light Extinction
INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)	
ISO 4406	(2021) Hydraulic Fluid Power - Fluids - Method for Coding the Level of Contamination by Solid Particles
ISO 11171	(2022) Hydraulic Fluid Power - Calibration of Automatic Particle Counters for Liquids
ISO ISO/IEC 17025	(2017) General Requirements for the Competence of Testing and Calibration Laboratories
U.S. ARMY CORPS OF ENGINEERS (USACE)	
EM 385-1-1	(2024) Safety -- Safety and Occupational Health (SOH) Requirements

1.3 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project.

The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "HDC" for the Hydroelectric Design Center MCX in Portland District, "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

In this SUBMITTALS paragraph below, choose the first bracketed item for Navy and Air Force projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Oil Test Independent Laboratory Qualifications; G,HDC

Oil Delivery Truck [And Temporary Contractor-Provided Clean Oil Storage Tank]Cleaning Methods; G,HDC[

Filtration Procedure(s); G,OPS,HDC]

OIL SAMPLING PLAN; G,OPS,HDC

Oil Spill Prevention Procedure; G,OPS,ECC,HDC

Oil Vendor Qualifications; G,HDC

Oil Delivery and Removal Procedure; G,OPS,ECC,HDC

SD-04 Samples

One Gallon Of Oil From Each Onsite Tank Or Truck; G,OPS

SD-06 Test Reports

[INITIAL COMPATIBILITY TESTING; G,HDC

] Data Of Chemical And Physical Characteristics, Per Delivery; G,HDC

Compatibility Testing Results, Per Delivery; G,HDC

SD-07 Certificates

[Certification Of Brand Name Product; G,HDC

] Certification Of Clean Oil Delivery Truck, Per Delivery; G,HDC,OPS

Chain Of Custody, Per Delivery; G,OPS

1.4 OIL TEST INDEPENDENT LABORATORY QUALIFICATIONS

Submit for approval the qualifications of the proposed oil testing laboratory, within 60 days of Award. The laboratory must be independent of [oil manufacturer][ExxonMobil][Shell][Chevron] and independent of the Contractor. The laboratory must be ISO ISO/IEC 17025 certified, and must have a minimum of 3 years of experience performing the ASTM D7155 Tier 1 Visual Appearance compatibility testing (note that this Tier 1 testing is not certified by ISO). Examples of qualifying laboratories are:

TestOil, 20338 Progress Drive, Cleveland, OH 44149, (216) 251-2510

SGS Herguth Laboratories, 101 Corporate Place, Vallejo, CA 94590, (800) 645-5227

Lubrication Engineers, 1919 E. Tulsa Street, Wichita, KS 67216, (800) 537-7683

MRT Laboratories, 305 Nebraska Street, South Houston, TX 77587, (713) 944-8381

1.5 OIL DELIVERY

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NOTE: Quarantining the oil in Contractor storage

reduces the risk taken on by the Government. In a case where the oil fails compatibility, any tanks that held the incompatible oil will need to be thoroughly cleaned prior to accepting more oil. By utilizing Contractor-provided storage tanks, it can be ensured that the Government tanks will not be contaminated by incompatible oil. This also puts the entire chain of custody of any rejected oil in the hands of the Contractor.

However, using Contractor-provided temporary oil storage also adds cost and increases the need for oil spill prevention measures. It may be an added burden for the Project to inspect daily for leaks, for instance. There are various ways to reduce everyone's risk, depending on the partnering relationship, costs, and quantity of oil. For example, if several railcars (20-24k gallons of oil) are being ordered, and the distributor has a tank farm with rail spurs, they may be able to hold a railcar from the manufacturer pending a set of test results to be approved by the Government. Then the distributor takes custody of the oil from the manufacturer, pumps it into clean tanks for filtration, submits cleanliness measurements to the Government, then pumps it into clean trucks for delivery, takes a sample from the truck at delivery, pumps it into the Government's clean tank, where it is quarantined pending acceptable test results from that sample. This way, Government acceptance of the oil depends only on factors which were in the Contractor's control. However, the Contractor must have confidence in their process, because rejection will mean the oil must be removed from the Government's tank and replaced at no additional cost to the Government. Also in this case the Government's tank should be cleaned, pumping or vacuuming out all oil and using squeegees and/or lint-free rags to wipe surfaces clean. Cleaning Government tanks prior to accepting the first delivery of new oil into them is good practice in any case. If other on-site work is already required in the contract, it might be worth requiring the Contractor to perform this work, which likely includes tanks which are confined spaces.

In any case, the samples used for final Government acceptance of the oil should be taken after the oil is onsite at the Powerhouse, to avoid accepting oil which is then contaminated during delivery. (One exception might be a tote which was filled and shipped directly from the oil manufacturer, which is sealed with no opportunity for contamination between the manufacturer and the Project.)

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[All oil deliveries will be held in Contractor-provided temporary onsite storage for up to one week after submittal of lab test results in order to allow for review and approval.][Oil will be held in Government storage

tank pending acceptable test results. If test results are unacceptable, remove the oil from the Government tank and replace it within 12 weeks at no additional cost to the Government.] Particular lab test results required include both property testing and compatibility testing as specified below.

1.5.1 OIL DELIVERY TRUCK [AND TEMPORARY CONTRACTOR-PROVIDED CLEAN OIL STORAGE TANK]CLEANING METHODS

Submit for approval the specific cleaning fluid and methods which will be used to clean oil delivery trucks and the qualifications of the truck cleaning company, within 60 days of Notice of Award. Include a description of how the cleaning procedure results in zero residue and therefore minimizes risk of contamination of new oil. Include a description of what documentation will be offered to serve as certification that a delivery truck was cleaned. Cleaning methods must include but not be limited to the steps outlined in paragraph Oil Delivery Truck [and Temporary Contractor-Provided Clean Oil Storage Tank] Cleaning or approved equivalent procedure.

Once the delivery truck, hoses, and pump(s) have been cleaned the first time per these specifications, if no products other than [the approved oil][name brand (if justified) e.g. Mobil DTE, Shell Turbo T68] have been transported by this equipment as evidenced by the manifests, then additional cleaning is not needed between loads.

1.5.1.1 Oil Delivery Truck [and Temporary Contractor-Provided Clean Oil Storage Tank] Cleaning

(a) Drain each compartment and discharge line.

(b) Use one of the following as a cleaning fluid:
(i) clean unused diesel fuel with less than 0.1% biodiesel and less than 0.2% total additives
(ii) kerosene
(iii) gasoline
(iv) jet fuel

(c) For tanks or single-compartment trucks, utilize a minimum of 50 gallons of cleaning fluid in the compartment. For triple-compartment trucks, utilize a minimum of 10 gallons of cleaning fluid in each compartment.

(d) Introduce cleaning fluid from the top of each compartment, such as by attaching a spinner ball or spray head to man-way on top of compartment. Attach the discharge hose to the discharge port of the compartment. Circulate the cleaning fluid through the discharge hose to the spinner ball or spray head. Repeat this for a minimum of 30 minutes. If there are multiple discharge ports, clean each discharge port (i.e., circulate the cleaning fluid through each discharge port during the cleaning process).

(e) After cleaning process is complete, discharge the cleaning fluid through the discharge hose to a proper container.

(f) After cleaning, check the compartment for residual product, emulsion, dirt, strong odor, or foreign debris. If compartment does not look clean, repeat flushing procedure.

(g) After cleaning, drain all discharge ports on the transport, including all manifold points of discharge and all internal valves opened, and check for residual product or diesel fuel. Slight elevation of the transport front will facilitate drainage. Total residual cleaning fluid remaining in the entire transport or tank must not be more than 5 gallons.

(h) Use a nitrogen or dry compressed-air blowdown.

1.5.1.2 Onboard Hose Cleaning

(a) Drain and flush all hoses used to deliver product with cleaning fluid. Inspect, and repeat as needed until clean.

(b) Drain cleaning fluid from hoses and blow dry with nitrogen or air.

1.5.1.3 Onboard Pump Cleaning

(a) Clean pump to be visibly free of dirt, water, or other contamination.

(b) Pump a minimum of 4 gallons of [approved oil][name brand (if justified) e.g. Mobil DTE, Shell Turbo T68]. Oil used for pump flushing may be of any viscosity.

1.5.2 DELIVERY HOSE REQUIREMENTS

Hoses must have a rated pressure of no less than 125 psi or 150 percent of the relief valve setting on the delivery pump system, whichever is greater. Delivery hose must be not less than 2 inches in nominal diameter. Hoses must be cleaned by a rag or pig to remove any loose visible contamination including dirt, sludge, varnish, lint, metal or any other visually observable debris. Before connecting the hoses allow the Government to visually check to confirm that the cleaning has occurred.

[1.5.3 FILTRATION PROCEDURE(S)

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NOTE: There is good evidence that filtration does eventually remove anti-foam additives from the oil regardless of the method used. Certainly it is preferable to filter oil that is above 50 degrees F and relatively dry. All other things being equal, higher flow rates seem to be beneficial in slowing removal of anti-foam additives. See also notes at paragraph PROPERTIES and paragraph DEGRADATION.

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Submit filtration procedure(s) no later than 30 days prior to filtering any oil. Procedures must follow oil manufacturer's recommendations and must include, but not be limited to, flow rates, temperatures, and filter information such as manufacturer, media, micron & Beta ratings. As applicable, differentiate between procedures for pre-delivery filtration at Contractor facility, pre-delivery filtration in delivery truck, onsite filtration in Contractor-provided temporary storage tank, and filtration during delivery through a filter cart.

]1.5.4 OIL SAMPLING PLAN

Obtain all samples per ASTM D4057 or ASTM D4177. See also paragraph OIL

TESTING AND SAMPLES. Submit for approval an oil sampling plan including but not limited to the following:

(a) Description of method of delivery (e.g. truck capacity, number of compartments) and onsite storage (e.g. Contractor-provided temporary double-walled storage tank) for each delivery of [_____] gallons of new [approved oil][name brand (if justified) e.g. Mobil DTE, Shell Turbo T68].

(b) Procedure to take oil samples for acceptance testing and for the Government (e.g. truck driver will pull sample with equal parts of oil coming from each oil compartment, with Government witness, and will label the container with the date and product name).

Procedure to provide clean sample bottles to the Government for in-service oil from [_____] Power Plant for compatibility testing (e.g. shipped directly from testing lab).

1.5.5 OIL SPILL PREVENTION PROCEDURE

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NOTE: A spill prevention RESPONSE plan (who to call, cleanup) should also be submitted per the environmental specification complying with site specific environmental concerns and requirements. Any other requirements or plans per the environmental specification or PDT's ECC should also be submitted. Compliance with the Clean Water Act is a HIGH priority.
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Submit an Oil Spill Prevention Procedure no later than 30 days prior to delivery, including but not limited to containment around the delivery truck, product data for oil spill prevention materials to be brought onsite, planned placement of oil socks/diapers, taping plastic around any hose connections, and plugging any drains being crossed by the hoses. The work must also include spill prevention for the truck, hoses, and any temporary storage tanks through which the oil is delivered, stored, and removed. Spill prevention must be in compliance with Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS. Spill prevention must be set up and observed by the Government prior to delivering or removing any oil.

1.6 OIL VENDOR QUALIFICATIONS

Submit qualifications certifying that the oil vendor:

(a) Is an Authorized Distributor of [approved oil][name brand (if justified) e.g. Mobil DTE, Shell Turbo T68], as indicated either on the distributor locator website or by a letter from [oil manufacturer][ExxonMobil][Shell][Chevron]

(b) Can prove through other documentation such as manifests, chain-of-custody documentation, and/or a letter from [oil manufacturer][ExxonMobil][Shell][Chevron], that the oil being provided is the exact name brand specified, AND;

(c) In addition to a or b, also has the ability to provide consistent timely turnaround on oil sample test results, as evidenced by a contracted relationship with, or a letter of commitment from, a

qualified testing lab or labs.

PART 2 PRODUCTS

[2.1 INITIAL COMPATIBILITY TESTING

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NOTE: As was noted above, compatibility between new oil and in-service oil must be evaluated and determined by lab testing. Only oils found to be compatible may be mixed with in-service oil or used as replacement oil. The compatibility testing is necessary, even when both base oils are mineral oils such as Group 1 and Group 2 oils, because the new oils currently readily available on the market may have been formulated with different additives, which may not be fully compatible with additives of the in-service oils. Compatibility testing for oil purchases of any significant volume is necessary even when replacing in-kind, as formulas change over the years. This paragraph is included in brackets in case the decision has been made to have initial compatibility testing performed by the Contractor. "Equivalency" of another product cannot be established without repeating all of this testing, because oil manufacturer's additive package "recipes" are proprietary. If there is a need to switch from one new oil to another new oil mid-way through the contract (for instance due to manufacturer stopping production of original product), this testing must be conducted between new oil #1 and new oil #2 as well as between new oil #2 and the in-service oil.

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Do not purchase any oil, other than in quantities required to perform testing, prior to Government approval of initial compatibility testing results from an approved independent oil testing laboratory. Coordinate with the Contracting Officer to provide sample container(s) to the proper address and to have sample(s) of in-service oil shipped to the laboratory for evaluation of compatibility between the two oils. Perform compatibility evaluation in accordance with ASTM D7155, including the following tests for each of the seven mixtures listed below:

From Tier 1 Visual Appearance, all tests.
From Tier 2 Interfacial Properties, all tests.
From Tier 3 Physical/Chemical Properties, ASTM D445 or ASTM D7042, and ASTM D664 or ASTM D974.
From Tier 4 Performance Properties, ASTM D2272, ASTM D665, [and ASTM D130][ASTM D130, and ASTM D4310].

Oils which fail to demonstrate compatibility with the in-service oil at [_____] Powerhouse per ASTM D7155 will not be approved for purchase. Perform all the tests listed above with each of the following seven ratios:

100 percent new oil to 0 percent in-service oil
95 percent new oil to 5 percent in-service oil
90 percent new oil to 10 percent in-service oil

50 percent new oil to 50 percent in-service oil
10 percent new oil to 90 percent in-service oil
5 percent new oil to 95 percent in-service oil
0 percent new oil to 100 percent in-service oil

Do not purchase any oil other than the exact name brand of oil which has been approved by the Government as being compatible with in-service oil. No "equivalent" products are acceptable for this requirement.

][2.2 CERTIFICATION OF BRAND NAME PRODUCT

Submit certification such as a letter with the manufacturer's certificate of analysis, Product Data Sheet (PDS), and Material Safety Data Sheet (MSDS) attachments that the product to be delivered per these specifications is the exact brand name specified. No "equivalent" products are acceptable for this requirement.

]2.3 GENERAL REQUIREMENTS

2.3.1 Properties

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NOTE: In recent years, it has become apparent from test results that filtering oil to the desired cleanliness levels DOES remove anti-foam additive. Cleanliness levels are more important than foam for equipment life. It may be necessary to check whether oil level sensors are susceptible to false readings in case of foam (e.g. ultrasonic, laser). Removal of anti-foam additive affects the foam "tendency", meaning how much foam is formed, but should not significantly affect foam "stability", or how long the foam lasts. Therefore, if the Contractor is to filter new oil, the foam tendency test results must be FIO (though the foam stability test results are still "G"). If the Contractor is not required to filter new oil prior to delivery, then the foam tendency results are "G" (as well as the stability results) but the cleanliness and water content results are FIO.
****

Provide turbine oil which is a blend of virgin petroleum-based stocks plus additives, free of [zinc and]chlorine, resulting in high-grade turbine oil having anti-rust and anti-oxidation properties suitable for use in hydraulic turbines, generator bearings, Kaplan turbine hubs and related applications. Chemical and physical characteristics of oil must meet or exceed the requirements listed in TABLE 1, [with the exception that foam tendency results are FIO][with the exception that cleanliness and water content results are FIO]. Determine oil characteristics by tests conducted in accordance with the tests methods as noted in the table.

2.3.2 Chemical And Physical Characteristics

The turbine oil must conform to the requirements established in TABLE 1 when tested according to the standards indicated. Submit certified test data showing that the oil meets or exceeds characteristics values specified in TABLE 1.

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NOTE: This table must be tailored depending on the actual oil chosen, in particular with respect to the RPVOT value and Acid Number. If there is a wide range of allowable turbine oils, add a requirement that the values for these characteristics must be within either 10 percent of the manufacturer's published value or within the manufacturer's quality control limits (in case values are not published) for new, unused oil.

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TABLE 1: CHEMICAL AND PHYSICAL CHARACTERISTICS REQUIREMENTS AND TEST METHODS FOR RUST AND OXIDATION (R&O) INHIBITED ISO 68 & 100 TURBINE OILS

Chemical and Physical Characteristics	**Requirements ISO 68 Oil**	**Requirements ISO 100 Oil**	**Test Method**
Viscosity at 40 C, centistokes (cSt)	65 - 70	95 - 102	ASTM D445 or ASTM D7042
Viscosity Index, minimum	98	95	ASTM D2270
Flash Point, minimum, C (F)	204 (400)	210 (410)	ASTM D92
Pour Point, maximum, C (F)	-9 (16)	-9 (16)	ASTM D97
Acid Number (AN) mg KOH/g, maximum	0.15	0.15	ASTM D664 or ASTM D974
Oxidation Stability by Rotating Pressure Vessel Oxidation Test (RPVOT), minutes, minimum	500	500	ASTM D2272
Rust Preventive Characteristics, Procedures "A" and "B"	Pass	Pass	ASTM D665
Water Content, parts per million (ppm), max	100	100	ASTM D6304
Water Separability of Petroleum Oil	40-40-0 (30)	40-40-0 (60)	ASTM D1401
Corrosion from Oil by Copper Strip Tarnish Test	Class 1	Class 1	ASTM D130
Foaming characteristics after 5 minutes blowing period:			
Sequence 1, foam volume in ml, maximum	100	100	ASTM D892 (Option "A" excluded) NOTE: These numbers are the foam "tendency" results.
Sequence 2, foam volume in ml, maximum	50	50	
Sequence 3, foam volume in ml, maximum	100	100	
Foaming characteristics after 10 minutes settling period:			

TABLE 1: CHEMICAL AND PHYSICAL CHARACTERISTICS REQUIREMENTS AND TEST METHODS FOR RUST AND OXIDATION (R&O) INHIBITED ISO 68 & 100 TURBINE OILS			
Chemical and Physical Characteristics	**Requirements ISO 68 Oil**	**Requirements ISO 100 Oil**	**Test Method**
Sequence 1, foam volume in ml, maximum	10	10	ASTM D892 (Option "A" excluded) NOTE: These numbers are the foam "stability" results.
Sequence 2, foam volume in ml, maximum	0	0	
Sequence 3, foam volume in ml, maximum	10	10	
Air Release Properties, minutes, max.	30	60	ASTM D3427
Cleanliness, Reported per ISO 4406 as Iso Code Particle Count, for particles greater than 4, 6, and 14 m (c)	17/15/12(c)	17/15/12(c)	ASTM D7647 (ISO 11171 Cal)
Appearance	Clear and Bright	Clear and Bright	Visual Observation

2.4 DEGRADATION

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NOTE: In recent years, contracts for turbine oil replacement have required that the Contractor deliver oil to 17/15/12 cleanliness, and also test delivered oil for properties & characteristics. Results from this have shown that filtration will affect "foam tendency" significantly due to removal of anti-foam additives (especially if oil is filtered with high water content). But even though the removal of anti-foam additives will tend to allow more foam to be generated (tendency), that foam should still subside when the oil is at rest - in other words, "foam stability" should NOT be significantly affected by the removal of the anti-foam additive.

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The physical and chemical properties of the oil, with the exception of foam tendency, must not be degraded (changed from the specified values) by filtration through two-micron mechanical type filters, by centrifugal purification, two-micron coalescing filters, balanced charge agglomeration or by vacuum type purifier, all of which have been designed for turbine oil.

2.5 HOMOGENEITY

Additive agents must remain uniformly distributed throughout the oil at all temperatures above the pour point and up to 120 degrees C 250 degrees F. When the oil is cooled below the pour point, it must regain homogeneity while standing at temperatures of 5 degrees C 10 degrees F above the pour point, and retain clear and bright appearance.

PART 3 EXECUTION

3.1 OIL TESTING AND SAMPLES

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NOTE: Actual testing plans, pre-advertisement, pre-award, and/or during contract, can vary depending on the details of the situation. Please consult with the proponent.

Due to the cost to perform testing on oil, it is recommended to provide an estimate to the number of tests required throughout the life of the contract.

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3.1.1 Data of Chemical and Physical Characteristics, Per Delivery

As a rough estimate for information only, [_____] of these submittals are expected to be required overall.

Furnish certified test data, for the [approved oil][name brand (if justified) e.g. Mobil DTE, Shell Turbo T68], showing results for all the values specified in TABLE 1. The certified test data must be submitted for approval within five business days after the delivery unless otherwise approved. This testing is required for each delivery of oil; differentiate the submittals using an identifier such as a delivery date and powerhouse name. A new submittal is required for each delivery.

3.1.2 Compatibility Testing Results, Per Delivery

As a rough estimate for information only, [_____] of these submittals are expected to be required overall.

Furnish certified test data, showing compatibility results for each delivery of oil per ASTM D7155 Tier 1, visual rating, using blends of in-service oil and new oil the ratios 100/0, 90/10, 50/50, 10/90, 5/95 and 0/100; include results for all six samples (the two "neat" oil samples and the four mixtures). Each compatibility test requires a sample of the powerhouse's in-service oil, which will be furnished by the Government, in a Contractor-furnished one-gallon sample container. Use one gallon of new oil from each delivery, which is a blend of oil from each container used in the delivery, e.g. if oil is delivered by a tanker truck with one extra tank, the gallon used for this testing should be half from the truck and half from the extra tank. The certified test data must be submitted for approval within ten business days after each delivery of oil unless otherwise approved. This testing is required for each delivery of oil; differentiate the submittals using an identifier such as a delivery date and powerhouse name.

3.1.3 One Gallon of Oil From Each Onsite Tank or Truck

As a rough estimate for information only, [_____] of these one-gallon samples are expected to be required overall.

Submit a one-gallon sample of the oil from each container in the truck at each delivery. Sample is to be obtained in a manner specified in ASTM D4057 or ASTM D4177. Contractor may submit a single gallon of evenly mixed oil from all containers if desired - e.g. if oil is delivered by a tanker truck with one extra tank, a single gallon, comprised of a

half-gallon from the truck, and a half-gallon from the extra tank, may be submitted rather than two separate gallons. This sampling is required for each delivery of oil; differentiate the samples using an identifier such as a delivery date on the sample container.

[3.2 FILTRATION

In all cases, including at Contractor's facility if applicable, warm oil to a minimum of 50 degrees Fahrenheit prior to filtration.

]3.3 DELIVERY OF NEW OIL

Deliver new oil in accordance with specifications and in coordination with the Contracting Officer for the delivery schedule. Spill prevention must be set up and observed by the Government prior to delivering any oil.

3.3.1 Oil Delivery and Removal Procedure

[Coordinate with the Contracting Officer regarding best location for oil delivery and removal trucks onsite.][Park oil delivery and removal trucks as close as possible to the oil fill/discharge cabinet in the erection bay.][Use a filtration cart with calibrated particle counter during each oil delivery. Deliver new oil at a minimum of 50 degrees Fahrenheit through the filtration cart.]Submit a detailed Oil Delivery and Removal Procedure for new oil deliveries and for the used oil removal[, including but not limited to product data on the filtration cart, product data on the filters themselves, product data on the particle counter, and calibration certificate for the particle counter per ISO 11171]. Include details regarding how used oil will be removed and disposed of. Set up oil delivery truck inside erected truck spill containment. Set up spill containment for the hoses prior to connecting and routing the hoses. All spill prevention equipment and provisions must be approved by the Contracting Officer prior to delivering oil. Take samples at each delivery of new oil as specified herein.

3.3.2 Chain of Custody, Per Delivery

Upon delivery of oil, provide a chain of custody report that includes documentation such as the bill of lading. Reports must track the oil, referenced by its batch number, from its origin to final delivery signed and dated by a designated representative. In the event of a failed compatibility test, this will be used to investigate when the oil was contaminated. Submit chain of custody at each delivery; use dates to differentiate among submittals.

3.3.3 Certification of Clean Oil Delivery Truck, Per Delivery

As a rough estimate for information only, [_____] of these submittals are expected to be required overall.

Prior to pumping oil into a powerhouse, submit certification that the truck used for that particular delivery was cleaned per the approved procedure, and that only [approved oil][name brand (if justified) e.g. Mobil DTE, Shell Turbo T68] has since been introduced into the truck. [This may be submitted electronically at the time the truck is being filled with oil for this contract, or may be submitted physically at the time of delivery.] Note that rejection of truck cleanliness constitutes rejection of oil delivery, unless otherwise approved in writing by the Contracting Officer.

[3.3.4 Temporary Onsite Oil Storage

Provide means of temporary new oil storage to hold approximately [_____] gallons of new oil or leave oil truck tankers on site as new oil storage while compatibility testing is performed. Provide means of temporary used oil storage to hold approximately [_____] gallons of used oil, and remove used oil once the Project is ready to dispose of it. Oil containment measures must be provided with any form of temporary storage except in the instance of a double-walled tank. Coordinate with Project personnel for staging locations.

Upon Government approval of oil delivered to temporary onsite storage, pump approved oil into the Government's storage tank.

]3.4 INSPECTION AND ACCEPTANCE

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NOTE: The Corps' Districts/Projects may perform Quality Assurance (QA) tests on samples taken at the delivery point. The QA tests should include, as a minimum, the viscosity, acid number, elemental spectroscopy, and oxidation stability. Any of the other tests in TABLE 1 are beneficial and should be considered in addition to the minimum QA tests. Samples should be taken from each bulk shipment and from not less than 10 percent of the drums taken at random from drum shipments. Such samples should be not less than 4 L 1 gal, which may be stored in more than one sample container, and a portion of each sample should be saved for later confirmation tests in the event that the results from the first tests indicate that the oil does not meet the specification requirements.

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At the point of oil delivery, the Government will obtain samples in a manner specified in ASTM D4057, and may perform such tests as are deemed necessary to determine whether the oil meets compatibility requirements as well as the specifications values listed in TABLE 1. The delivered oil must remain in a storage tank (if applicable) and cannot be used until the test results are received from the laboratory. Should the oil fail to meet requirements, or show results incompatible with being the specified name brand required, or be so contaminated at the delivery point that it fails compatibility testing with in-service oil, the Contractor is responsible for removing oil[, cleaning Government tanks used to store that oil,] and disposing of the rejected oil and replacing the oil at no additional cost to the Government, within 3 months of initial delivery.

[3.5 TANK CLEANING

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NOTE: Do NOT permit the use of any detergents in cleaning tanks, or any turbine oil-containing equipment. Do NOT permit the use of engine oil either, because engine oil is HIGHLY additized, including detergents and dispersants that will contaminate the turbine oil. Even pipe dope, cosmoline, and other common substances or residues

on piping equipment should be prevented from contaminating turbine oil-containing equipment. Any of the cleaning fluids allowable per paragraph OIL DELIVERY TRUCK [AND TEMPORARY CONTRACTOR-PROVIDED CLEAN OIL STORAGE TANK]CLEANING METHODS is acceptable as an interim measure, but the final cleaning should be with lint-free absorbent rags.

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[In the event that new oil was allowed to be stored in the Government's storage tank at the power plant, and that oil subsequently fails to meet criteria and is rejected by the Government, clean the Government tanks after removal of rejected oil.

][Clean the two xx,xxx-gallon transformer oil storage tanks.][Clean the xx,xxx-gallon Clean Lube Oil Storage Tank prior to any oil deliveries.][Clean the xx,xxx-gallon Dirty Lube Oil Storage Tank after all used oil has been removed from the powerhouse.]Tanks must be thoroughly manually cleaned by the Contractor. The Contractor is to physically clean and wipe out all residues from the tanks using oil-absorbent and lint-free cloths to remove all visible dirt, varnish, and debris, to the point that no residual contamination can be detected on clean lint-free white cloths. If desired, the Contractor may propose for the Contracting Officer's approval, use of their own equipment other than cloths as a first cleaning, such as a vacuum, squeegee system or pump. This may be necessary to remove oil from the very bottom of tanks. Detergents may NOT be used. Engine oil (which is highly additized including detergents) may NOT be used at all, not even on rags used to clean the tank. In any case, the final cleaning must be performed manually with oil absorbent and lint-free cloths. In this process, coordinate work with the Contracting Officer, perform all work in accordance with [SECTION 01 11 01.00 XX SUPPLEMENTARY REQUIREMENTS], and comply with all confined space requirements and procedures. The plan must be a complete plan in accordance with 29 CFR 1910 and EM 385-1-1. Cleaning of tanks is to be considered completed when inspected and approved by the Contracting Officer.

]3.6 REMOVAL OF USED OIL

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NOTE: Removal of used oil typically requires about a week's notice. The truck used to remove oil is typically completely separate from the delivery truck, and is subcontracted out. It is desirable for the contract to have flexibility regarding the total number of truckloads to be removed, and to allow for a final oil removal with less than a truckload, which will affect pricing for that load.

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Remove and properly dispose of up to [_____] 8,000-gallon truckloads of used oil from the Powerhouse. With the truck parked inside the powerhouse as close as possible to the oil [supply/discharge cabinet connections][storage tanks] as directed by the Government. Approximately [_____] gallons at a time of existing used oil will be pumped to the truck. Dispose of oil offsite in accordance with applicable laws and regulations. Coordinate with the Government prior to arriving on-site for final staging locations.

-- End of Section --