SPECIFICATION FOR ADJUSTABLE-SPEED SUBMERSIBLE MIXER - DIRECT DRIVE

GENERAL REQUIREMENTS

Furnish and install _____ submersible mixer(s). Each mixer shall have a submersible electric motor with rated power _____ kW, connected for operation to the following power supply: _____ volts, _____ phase, _____ Hz. The mixer shall be capable of delivering a range of thrusts from _____ N (newton) at _____RPM to _____ N at _____RPM. The mixer shall be designed for continuous duty in handling mixed media with a maximum temperature of 104 ^{o}F. The mixer shall be equipped with a submersible cable, sized according to IEC standard, having a chlorinated polyethylene rubber jacket, and having a length of _____feet.

MANUFACTURER REQUIREMENTS

The mixer specified herein shall be the design and fabrication of a single manufacturer which shall have sole source responsibility for said equipment. The manufacturer shall have mixing equipment of comparable capacity in successful operation in the field for a minimum period of 10 years.
The factory producing the mixing equipment shall be certified according to ISO 9001 (quality): ISO 14001 (environmental) and OHSAS 18001 (occupational health and safety) standards.

MIXER DESIGN

The mixer shall be capable of handling any type of raw sewage. It shall be possible to easily raise and lower the mixer without the need for personnel to enter the tank. The mixer shall be mounted on a square or rectangular guide bar system. The mixer, with its appurtenances and cable, shall be capable of continuous submergence without loss of watertight integrity to a depth of 20 m. Major mixer components shall be made of stainless steel AISI 316 or better.
Nuts and bolts shall also be made of stainless steel

PERFORMANCE

All the mixers offered shall be capable of producing _____ Newton of thrust at ____RPM maximum. Mixers requiring higher rotation speeds to produce this thrust are not acceptable. Speed must be field adjustable while the operator is on the walkway near the tank perimeter.

The specific performance requirement for each mixer offered is outlined in the table below:

Tank Designation	**Maximum Mixer Speed (rpm)**	**Maximum Energy Consumption (kW)**	**Minimum Energy Efficiency (Newtons/kW)**

The manufacturer must be able to prove this performance in accordance with ISO 21630:2007 and provide an official report upon request.

MOTOR AND DRIVE
The motor shall be a high efficiency synchronous speed permanent magnet type with an integrated variable speed drive, housed in an air filled, watertight chamber. The motor is to be purpose built for underwater operation by the mixer manufacturer. The motor efficiency shall be equivalent to IEC standard 60034-30-01 for international efficiency, class IE4 levels. The mixer speed shall be adjustable via either remote communications or a separate operator panel. The motors power electronics shall be capable of continuously monitoring load and temperature of the motor, and to temporarily reduce speed until overload or overheat condition is relieved and then resume normal operation without any operator intervention. The stator windings and stator leads shall be insulated with moisture resistant Class H (356°F) insulation. The stator shall be impregnated with class H varnish and shall be press fitted into the stator housing. The motor shall be capable of an unlimited number starts per hour.

POWER CABLE
The mixer shall be equipped with a screened submersible cable, sized according to IEC standard, having a chlorinated polyethylene rubber jacket. The cable shall be chemical resistant within pH of 3 to 10 and shall be ozone, oil, and flame resistant. The power cable shall have four screened control cores

CABLE ENTRY
The cable entry shall be positioned on the top of the mixer to avoid a bend on the motor cable when routed to the top of the tank. The cable entry seal shall consist of cylindrical elastomer bushings, without epoxies, silicones or other secondary sealing systems.

BEARINGS
The motor shaft shall rotate on two permanently lubricated bearings with shielded design. The main bearing shall be a two-row angular contact ball bearing to take up axial and radial loads. The support bearing shall be a single row deep groove ball bearing.

MECHANICAL SEALS
Each mixer shall be provided with a liquid chamber for the shaft sealing system. Each mixer shall be provided with a dual mechanical shaft seal system consisting of two independent seals assembled into one plug-in unit. The seals shall operate in a liquid reservoir that hydro dynamically lubricates the seal faces at a constant rate. The outer seal shall have rings of corrosion resistant cemented carbide (WCCR) or silicon carbide (RSiC). Only the outer seal shall be exposed to the mixed media. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment. One face of the inner seal ring pair shall have spiral grooves laser etched in it, to provide a pumping action preventing leakage from the oil chamber to the stator housing.

OIL
The oil chamber shall be filled with a medical white oil of paraffin type. The oil shall be free from aromatic hydrocarbons and be approved according to FDA 172.878.

PROPELLER SHAFT
The propeller shaft and motor shaft are to be a single unit and shall be made of stainless steel ASTM/AISI 431 or comparable.

PROPELLER
The mixer shall have a three-bladed propeller made of stainless steel 316 with a back swept, clog resistant and high efficiency hydrodynamic design. The propeller shall be capable of handling solids, fibrous materials, heavy sludge, and other matter found in normal sewage applications. The fit between the propeller and the shaft shall be a sliding fit. The sliding fit will assure that no special tools will be required to remove the propeller.

PRODUCT TESTING
The manufacturer shall have the capability of acceptance testing the mixer regarding thrust and power according to ISO 21630:2007, on request. The mixer manufacturer shall perform the following inspections and tests on each mixer before shipment from the factory:

1. Tightness test of the assembled mixer using a vacuum method.
2. Dry-run test to establish mechanical integrity and correct rotation.

The manufacturer shall on request be able to provide a written report stating that the foregoing steps have been done for each mixer at time of shipment.

MIXER POSITIONING
Manufacturer is to analyse the configuration of the customer's tank(s), and provide detailed recommendations, in the form of a drawing showing the optimal placement and orientation of the mixer(s) being offered for the specific tank and application.

MOUNTING
The mounting system is to be guide bar type, bottom mounted or tank wall mounted, in either hot dip galvanized steel, 304 or 316 stainless steel. The guide bar system must be configured to allow for easy lifting by davit crane up the guide bar and out of the tank for servicing without draining the tank. When the mixer is in place, it should rest on a support arm designed to carry the mixers full weight and minimize movement from unbalanced or intermittent torsional forces.

ON SITE SERVICES
The manufacturer or their representative is to verify proper installation and positioning of the mixer upon start-up, and provide operators with training on how to operate and maintain the mixer(s).

REMOTE COMMUNICATIONS
The mixer shall be capable of communicating with a SCADA or other machine communication systems either directly or via a vendor provided communications "gateway". Communication should be using Modbus RTU or TCP communications structure. The mixer communication protocol is to be designed to operate with, or without, a master controller. Allowed commands must include start, stop, reference speed and configuration of settings. An intermittent signal should be provided to verify connectivity with the mixer. Parameters that must be readable remotely include:

- Current Motor Power Consumption
- Cumulative kW – hours
- Running hours
- Alarm Status
- Alarm Details
- Mixer over temperature
- Overcurrent (excessive load)
- Communication failure
- Power electronics (VFD) diagnostics
- Leakage alarm

Controls must give the operator the ability to define how the mixer reacts to a leakage alarm, and to set a ramp up and ramp down time for the soft start and stop functions
The mixer must also be user configurable to either start on its own whenever 3 phase power is provided or require re-established communications before resuming. All settings must be stored in

non-volatile memory within the mixer enabling it to resume normal operation when power is restored even if communication is not.

The mixer vendor must provide a kit for mounting the mixer controls in an existing panel, or alternately a compact control panel suitable for outdoor use.

COMMUNICATIONS GATEWAY

Each mixer shall be supplied with a gateway that links to the mixer (1 gateway per mixer). A set-up wizard shall guide the user through the process of matching mixer to gateway. It shall have contextual help screens built in.

Gateway shall offer at least 1 x USB, 1 x RS485 1 x Ethernet RJ 45 1 x Display interface, 4 x Digital outputs, 4 x Digital inputs, 1 x Analog input & output. Each gateway shall provide 2 wire connections for mixer communication. Gateway housing shall be built to protection class IP 20 and able to operate in ambient temperature of -4 ˚F to +140˚F. The supply power to the Gateway shall be 24 V DC. The gateway shall have LED to indicate mixer alarms and the unit shall be capable of communicating these alarms to a control unit. Gateways have the UL/ CSA and CE marks and be designed and manufactured by the mixer supplier.

The Gateway shall include a USB service port for software updates and shall be capable of being mounted on DIN rail. The Gateway shall provide for operation of the mixer via:

a) Discrete digital and analogue I/O’s
b) Modbus RTU and TCP
c) Internal web server-based HMI
d) Locally mounted HMI

Gateway shall allow for alarms to be configurable as critical or warning. Configurable alarms will include:

a) Analog input under range
b) Analog input over range
c) Gateway start-up failure
d) Liquid leakage detected
e) Over temperature
f) Locked rotor alarm
g) Internal fault (#)
h) Motor fault (#)
i) Over current
j) Motor thermal overload
k) Heatsink over temperature
l) Under temperature
m) Phase loss
n) Over current drive output
o) Overload reduced speed
p) Leakage sensor fault
q) Factory default values set
r) Time for service

HUMAN MACHINE INTERFACE (HMI)

The HMI shall allow the operator to modify parameters via a jog wheel and enter button or via a touchscreen that is 178mm or larger.
The HMI shall have the UL/CSA and CE marks and be designed and manufactured by the mixer supplier.
The HMI will be able to operate in ambient temperature: -4˚F to +140˚F

USAGE OF EXTERNAL VARIABLE FREQUENCY DRIVE (VFD)

Mixers with integrated variable speed drives should never be attached to an external VFD. Mixers not containing integrated variable speed drives shall be provided with simplex, remote, variable speed control panel suitable for indoor control room mounting as well as a local control panel mounted on the walkway in the vicinity of each mixer. The remote panel shall be constructed in a NEMA 1 painted steel enclosure and include an adjustable speed controller that will vary the speed of the mixer based upon process input. It shall also include a main power distribution block, lightning arrestor, control transformer, motor circuit breaker with disconnect switch and motor starter. The local control panel shall be constructed in a NEMA 4X stainless steel enclosure. It shall include a keypad or potentiometer to vary the mixer speed, Hand-Off-Auto (HOA) switch, control relay to detect motor over temperature and leakage, alarm horn, alarm beacon and space heater. With the HOA switch in the Auto position the mixer speed will be controlled from the remote control panel. With the HOA switch in the Hand position the mixer speed will be controlled from the local keypad or potentiometer. With the HOA switch in the Off position the mixer will not operate.

The VFDs shall be preconfigured soft start and soft stop functionality. The VFD must monitor the mixer and be able to slow it down in response to excessive loads on the mixer blades, and return to normal operation when the excess load falls off, without operator intervention. The contractor shall be responsible for the compatibility and coordination of the mixers and the VFDs.

CFD (Computational Fluid Dynamics) Analysis

The Contractor shall submit the following information for review and approval:

License and Software

Proof of the employed CAD, CFD or any additional CFD Pre/Postprocessing software shall be shown on demand. This can include a copy of a paid license receipt or any other document supporting the claim. Finite volume based CFD software capable of multiphase modelling shall be used.

CFD model

Turbulence effects shall be represented with the help of realizable k-e (or other) model that provides an improved prediction for the spreading rate of both planar and round jets.

Submersible mixer shall be modelled appropriately and correctly account for generated thrust, torque and radial forces.

Apparent viscosity of the liquid shall lie between 1-10 cP based on the given TS concentration.
Computational mesh shall adequately represent relevant internal obstacle and tank geometry with 0.1 m as a maximum size of the computational element.

Wall effects shall be well resolved with the corresponding y+ value below 100. Gas-liquid two-way coupling shall be applied.

Reported results shall correspond to a converged numerical solution. Proof of convergence in a form of residual plot and volume average velocity magnitude shall be presented.

The volume average velocity shall be proven converged. The total air mass imbalance shall be maximum 5%. The total mass imbalance for net through flow cases shall be maximum 3%.

CFD results

The report shall describe problem at hand, agreed work scope and analysed scenarios. This shall include setup for each scenario, corresponding running conditions, flow rates, chosen mixer equipment and other relevant information.

For the sake of clarity, geometry shall be shown in different perspective (side, top and isometric), important dimensions shall be specified, and all relevant internal objects and obstacles shall be shown.

Boundary conditions and other modelling assumptions shall be presented and justified. Presented results shall build a solid understanding of the resulting flow pattern. Important flow features shall be visualized. Sedimentation risks shall be evaluated and, if necessary, addressed.
Air entrainment risks near mixers shall be evaluated. Volumetric mean age distribution shall be provided for net through flow cases in order to evaluate short-circuiting/stagnation risks.

To allow for independent audit of the numerical solution and to eliminate CFD model propriety risks, result files shall be, on demand, submitted in a format that is compatible with the Tecplot visual analysis tool.