BUILT TO SPEC' CHEMICAL FEED SYSTEMS

General Installation & Maintenance Guidelines

1317 PRINCETON BLVD,
ELKHART, IN, 46516

PH: (574) 295-4292
FAX: (574) 295-7562

EMAIL:
INFO@MADDENEP.COM

WEBSITE:
WWW.MADDENEP.COM

MADDEN ENGINEERED PRODUCTS

CHEMICAL FEED SYSTEMS - GENERAL GUIDANCE MANAUAL

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⚠ IMPORTANT — READ BEFORE STARTUP! ⚠

PLEASE READ THIS GENERIC MADDEN CHEMICAL FEED SYSTEM OPERATOR'S MANUAL IN FULL BEFORE PERFORMING ANY EQUIPMENT STARTUP, ADJUSTMENT, OR COMMISSIONING ACTIVITIES.

Madden Engineered Products has prepared this document to provide clear, practical, system-level guidance for chemical feed system operation.

- This manual is intended to help operators and maintenance personnel:
- Understand how the overall system functions
- Recognize common installation and startup issues
- Identify potential operating problems before damage occurs
- Establish safe and reliable baseline operation

This document reflects Madden's experience designing, fabricating, and integrating complete chemical feed systems.

⚠ **After reviewing this manual, operators shall then review and follow all applicable manufacturer-specific manuals for pumps, mixers, VFDs, instrumentation, and control equipment supplied with the system.**

(Madden Chemical Feed System designs include outsourced ancillary equipment along with equipment fabricated by Madden)

Manufacturer manuals govern internal limits, factory settings, and component-specific requirements and shall always be followed.

Failure to review and follow both this manual and the applicable OEM manuals may result in improper operation, reduced equipment life, or unsafe conditions.

SECTION 1 — INTRODUCTION / SAFETY GUIDELINES / SYSTEM OVERVIEW

1.1 Introduction

This manual provides general instructions for the installation, startup, operation, troubleshooting, and maintenance of Madden chemical feed systems. **This document is NOT system specific.** It is intended as a broad overview for systems using positive displacement diaphragm metering pumps of any brand, including Madden JN, MF, and MH series pumps, as well as commonly used third-party pumps from reliable brands such as Milton Roy, Neptune, ProMinent, and others.

System-specific documentation — including pump manuals, mixer manuals, VFD manuals, relief valve instructions, GA drawings, P&IDs, and electrical diagrams — is supplied separately during the submittal review and approval process. These documents shall always be followed for detailed requirements.

1.2 Safety Guidelines

- Follow all facility safety procedures and refer to SDS sheets for every chemical used.
- Only trained and qualified personnel should install, operate, or service chemical feed systems.
- Always wear appropriate PPE including gloves, goggles, face shields, and chemical-resistant clothing.
- Isolate electrical power before servicing equipment when safe to do so.
- Do not breathe chemical vapors; refer to SDS for ventilation requirements
- Avoid placing hands near rotating mixer shafts.
- Do not modify equipment without written authorization from Madden.
- In any emergency scenario, follow site-specific emergency procedures and contact appropriate facility personnel.

⚠ This manual does NOT override specific pump manufacturer instructions, facility engineering standards, water treatment program recommendations, or jurisdictional authority requirements.

1.3 System Overview

A chemical feed system injects a controlled quantity of treatment chemical into a process stream. Positive displacement diaphragm metering pumps provide accurate, repeatable flow regardless of discharge pressure (within pump limits).

Typical components may include:

- Chemical storage tank (HDPE or stainless steel)
- Mixer or agitator
- Positive displacement diaphragm metering pump(s)
- Relief valve and backpressure valve
- Pulsation dampener
- Calibration column
- Suction strainer or foot valve
- Control panel, VFDs, alarms, and switches
- Suction and discharge piping or tubing assemblies

1.4 Receiving, Handling, Storage

Store indoors whenever possible. Recommended storage environment: dry, covered; protect capillaries and gauges; source freeze protection if stored below 32°F (0°C).

If outdoors: cover with a tarp and ensure paint coating is intact.

Handle with forklift or lifting equipment that is sized appropriately for the system weight. Lift from baseplate, vessel body, or lifting lugs only (if applicable). Do not lift by nozzles or ancillary equipment connections.

1.5 Operator Responsibility

Operators must understand basic operation, safe handling of chemical dosing systems, and valve logic.

Madden does not control field installation practices or treatment program strategy and therefore cannot assume responsibility for how the system is installed, operated, or integrated into the facility's process.

Final responsibility for safe piping, sizing, vent discharge routing, utility balancing, and boiler blowdown rate remains with:

- The installing contractor
- The boiler manufacturer
- The facility engineer
- The water treatment company

SECTION 2 — INSTALLATION, STARTUP, OPERATION, & MAINTENANCE

2.1 General Handling, Receiving, & Installation

- Inspect equipment upon delivery for visible damage
- Verify all components listed in the submittal packet are present
- Protect gauges, valves, piping/tubing during handling
- Install systems on a level, rigid foundation capable of supporting the operating weight.
- Anchor skids to prevent movement and vibration.
- Ensure the installation area is protected from weather unless outdoor-rated components are used.
- Ensure suction piping is as short and direct as possible. Vertical rises on the suction line should be avoided unless specifically required.
- Provide flooded suction for best pump performance; suction lift should be minimized when applicable.
- Avoid excessive pipe strain on pump connections; use unions or flexible connectors as needed.
- Pipe relief valves back to a safe location, typically the tank or suction line, depending on design.
- Electrical connections must be performed by qualified electricians following all applicable codes and OEM instructions. Ensure installation is in a clean, accessible location for future inspection

Adequate operator access to the chemical holding tanks, pump and mixer motors, control panel (if applicable), ancillary instrumentation, and system outlet, relief return, and drain line MUST be maintained.

2.2 Commissioning & Startup

Before startup:

- Verify pipe connections are tight and correctly oriented.
- Confirm electrical power supply and motor rotation (if applicable).
- Prime the suction line with chemical or water to reduce air accumulation.
- Ensure mixers are unobstructed and chemical levels are adequate.

Initial Startup:

- Start the pump at low stroke or low speed.
- Gradually increase to required output.
- Crack open a downstream fitting or loosen a discharge union temporarily (when safe) to help purge air from the pump head during initial prime.
- Observe discharge pressure, flow stability, and pump cycling.
- Verify that the relief valve is functional and not lifting during normal operation.
- Check for leaks and correct immediately.

2.3 General System Operation Guidance

- Operate pumps within their intended stroke or speed range for best accuracy.
- Maintain a flooded suction when possible to prevent air lock.
- Allow mixers to fully disperse chemicals before feeding downstream.
- Monitor discharge pressure and adjust backpressure valves as required.
- Inspect relief valve discharge periodically for unexpected flow (indicating overpressure or obstruction).

2.3.1 Diaphragm Metering Pumps Operation – Pump Startup and OEM Documentation Compliance

This manual provides general guidance for chemical feed system operation. Detailed operating limits, internal protections, and factory settings are established by the individual pump manufacturers.

All operators and maintenance personnel shall review the applicable pump manufacturer's operating manual prior to startup and adjustment.

Manufacturer documentation governs internal component limits and shall always supersede general guidance.

A. Importance of OEM Manual Review:

Many metering pumps are supplied with factory preset features that affect startup and operation, including:

- Internal pressure relief valves
- Bypass systems
- Stroke limiters
- Electronic protection settings
- Shipping and storage configurations

These features may differ by manufacturer and model.

Failure to review OEM documentation may result in:

- Unexpected pressure relief
- Inability to reach desired operating pressure
- Improper calibration
- Reduced component life
- Equipment damage

B. Initial Pump Startup Procedure (General):

After reviewing the applicable OEM manual, the following general procedure applies:

- Verify correct electrical supply and motor rotation.
- Confirm all isolation valves are in proper operating position.
- Ensure suction line is primed and flooded where possible.
- Set pump to minimum stroke or speed.
- Start pump and confirm smooth operation.
- Gradually increase output while observing system response.
- Purge trapped air as recommended by the pump manufacturer.
- Monitor discharge pressure and flow stability.

C. Pressure Limits and Internal Relief Devices:

Some metering pumps are equipped with internal relief valves or bypass mechanisms that may activate at preset pressures.

These devices may:

- Limit maximum discharge pressure
- Return flow to suction
- Prevent external pressurization
- Mask downstream restrictions

Operators shall verify internal relief settings and operating behavior in accordance with OEM documentation before performing high-pressure testing or system pressurization.

2.3.2 Chemical Agitators/Mixers Guidance – Mixer Operation, Speed Control, and Agitation Guidelines

Madden chemical feed systems are typically supplied with integrated mixer assemblies consisting of a motor, gearbox, shaft, and impeller package selected for general chemical agitation and suspension service.

These mixers are intended to provide reliable, practical mixing performance for typical water treatment applications. They are not custom process agitators designed through detailed fluid dynamics analysis.

A. Initial Startup Behavior:

During initial startup, mixer motors and gearboxes may experience momentary torque loading as the rotating assembly accelerates to operating speed. This may result in brief movement or vibration of the bridge mount or support structure.

This behavior is most noticeable during fixed-speed, across-the-line motor starting.

Where practical, the use of soft-start devices or variable frequency drives (VFDs) is recommended to reduce mechanical shock loading and extend equipment life.

B. Agitation Characteristics in Unbaffled Tanks:

Most Madden chemical tanks are not equipped with internal baffles. When turbine-style impellers are used, this design promotes strong vertical circulation and bulk fluid movement rather than a narrow surface vortex.

This “churning” action is intentional and provides effective agitation and suspension for many chemical applications.

Compared to marine-style propellers, turbine impellers:

- Produce greater bulk circulation
- Reduce deep vortex formation
- Improve suspension in unbaffled tanks
- Increase overall mixing energy

This operating behavior is normal and expected.

⚠ C. Speed Control and VFD Recommendations:

Where supplied, VFDs allow operators to adjust mixer speed to match site-specific chemical properties and operating conditions.

Madden recommends the use of VFDs when possible to allow:

- Reduced startup shock
- Fine adjustment of agitation intensity
- Optimization with chemical suppliers
- Reduced long-term mechanical wear

In many applications, continuous operation at maximum mixer speed is not required.

⚠ D. Operation Without a VFD (Fixed-Speed Systems):

When mixers are operated at fixed speed without a VFD, operators should:

- SOFT START KIT ON A.C. MOTORS RECOMMENDED – Hard starting mixer motors may apply excessive startup torque to bridge-mounted or similar support structures
- Observe the mixer and support structure during operation
- Monitor for excessive vibration or movement
- Avoid unnecessary continuous high-speed operation
- Utilize intermittent mixing cycles where appropriate

If excessive agitation, vibration, or structural movement is observed, operators should consult Madden and/or the chemical supplier before continuing long-term operation.

In many cases, reduced duty cycles or timed operation may provide adequate mixing while minimizing mechanical stress.

E. Normal vs. High-Intensity Mixing:

Madden mixers are selected with sufficient capacity to allow occasional high-intensity mixing when needed for batch preparation, chemical blending, or suspension recovery.

Continuous operation at maximum speed should be avoided unless specifically required by the treatment program and confirmed to be mechanically acceptable.

Extended high-speed operation increases loading on:

- Gearbox bearings
- Shaft supports
- Bridge mount structures
- Motor couplings

Improper long-term operation may reduce equipment life.

F. Responsibility for Mixing Optimization:

Madden supplies integrated mixer assemblies intended for general agitation service.

Final optimization of mixer speed, duty cycle, and operating strategy shall be performed by the facility operator in coordination with the water treatment provider and chemical supplier.

Madden does not provide process-specific agitation design services and cannot assume responsibility for site-specific mixing performance beyond the supplied equipment ratings.

2.3.3 – Integrating Common Ancillary Equipment with System Instrumentation

Proper metering pump operation depends on correct interaction with system components, including:

A. Pulsation Dampeners

Pulsation dampeners reduce pressure fluctuations inherent in positive displacement pump operation and improve system stability.

Operators should:

- Verify proper pre-charge pressure (if applicable)
- Inspect for bladder or diaphragm damage
- Monitor for loss of damping performance
- Ensure isolation valves remain open
- Confirm dampener orientation

Common symptoms of improper dampener operation include:

- Excessive gauge needle movement
- Noisy piping
- Unstable flow
- Premature instrument failure

Dampeners that have lost pre-charge or internal integrity shall be serviced or replaced promptly.

B. Pressure gauges

Pressure gauges and instrument ports provide critical feedback during startup and operation.

Operators should:

- Verify gauge pressure ratings
- Inspect gauges for damage or drift
- Replace damaged or unreadable gauges
- Confirm gauge isolation valves are open
- Protect instruments from freezing
- Inaccurate or failed instrumentation may prevent early detection of abnormal operating conditions.

C. Backpressure and Relief Valves

Backpressure and relief valves are critical safety and performance devices.

Backpressure valves maintain minimum discharge pressure to ensure stable metering performance.

Relief valves protect the system from overpressure.

Operators should:

- Verify setpoints during commissioning
- Inspect relief discharge routing
- Confirm free movement of internal components
- Exercise valves periodically
- Monitor for unexpected lifting

Relief valves that discharge frequently under normal operation indicate downstream restriction or improper valve settings and shall be investigated immediately.

Relief discharge piping shall remain unobstructed at all times.

D. Flow Meters (If Installed)

Flow meters provide indication or verification of chemical feed rates and must be properly integrated with metering pumps.

Operators should:

- Verify minimum and maximum flow limits
- Confirm compatibility with chemical properties
- Inspect for fouling or scaling
- Maintain proper straight-run piping where required
- Protect from freezing and impact

Flow meters may be affected by:

- Pulsation
- Gas entrainment
- Temperature changes
- Viscosity variation

Observed discrepancies between calibration column readings and flow meter indication should be investigated before adjusting pump output.

E. Calibration Columns

Calibration columns are provided to verify actual pump output and assist in accurate pump adjustment.

Operators should:

- Ensure isolation valves to the column are fully operational
- Keep the column clean and free of chemical residue
- Verify visibility of graduations
- Drain and flush the column periodically
- Inspect for air bubbles or blockage
- Blocked or contaminated calibration columns may result in inaccurate flow readings and improper dosing.

Calibration should be performed using clean fluid whenever possible and in accordance with pump manufacturer procedures.

F. Y-Strainers and Foot Valves

Y-strainers and foot valves protect pumps from debris and maintain proper suction conditions.

Operators should:

- Inspect strainers routinely
- Clean screens as required
- Monitor for debris accumulation
- Verify foot valve check function

- Confirm secure suction connections

Clogged strainers and malfunctioning foot valves are common causes of loss of prime, cavitation, and reduced flow.

In systems with frequent plugging, upstream filtration or increased cleaning frequency may be required.

G. Ongoing Compliance

All adjustments to pump stroke, speed, pressure limits, or protective devices shall be made in accordance with OEM documentation.

When questions arise regarding pump behavior, operators shall consult the applicable manufacturer's manual and Madden technical support prior to continued operation.

2.4 Maintenance

NOTE: The maintenance guidance below is general. For specific pump rebuild intervals, lubrication requirements, torque values, replacement part identification, and detailed procedures, always refer to the individual operator's manuals and OEM data sheets provided in your project submittal package.

- Inspect pumps weekly for leaks, unusual sounds, or changes in discharge pressure.
- Replace diaphragms and valve kits per OEM recommendations or when performance changes.
- Ensure suction strainers and foot valves remain clean and unobstructed.
- Diaphragms naturally 'creep' during early operation. Retorque pump head bolts lightly during the first weeks of runtime (refer to pump manual for torque values)
- Verify calibration column accuracy periodically.
- Keep common wear parts (diaphragms, valve kits) stocked based on the specific pump model.
- Maintain clean electrical enclosures and ensure proper ventilation.
- Document all maintenance activities in facility logs.

SECTION 3 — TROUBLESHOOTING

Issue / Symptom	Likely Cause(s)	Recommended Solution(s)
Pump(s) Will Not Prime	• Air trapped in head • Suction line leak • Suction lift too high • Blocked foot valve or strainer • Incorrect valve orientation	• Verify flooded suction if possible • Tighten all suction fittings • Clean/replace foot valve screen • Refill suction line to remove air • Check valve orientation per pump manual
Pump(s) Loses Prime During Operation	• Low tank level • Suction obstruction • Gas entrainment • Loose connections • Excessive suction lift	• Restore tank level • Check suction piping for debris • Eliminate air/gas source upstream • Tighten fittings • Reduce suction lift height
No Flow / Low Flow	• Worn diaphragm • Worn valve seats/balls • Obstructed suction/discharge • Incorrect stroke/speed setting	• Replace diaphragm • Replace valve kit • Remove obstruction • Set stroke/speed per calibration
Flow Pulsation / Instability	• Gas pockets in discharge line • Backpressure valve not set • Insufficient discharge pressure for stable flow	• Adjust backpressure valve • Install/verify pulsation dampener • Bleed trapped gas
Excessive Noise or Vibration	• Air binding • Cavitation • Diaphragm wear • Pump misalignment • Mounting bolts loose	• Remove air from pump head • Reduce suction lift; ensure NPSA • Replace diaphragm • Check and tighten mounting hardware
Pump(s) Overpressure / Relief Valve Lifting	• Blocked discharge • Closed valve downstream	• Inspect discharge path • Confirm valves are open

	• Frozen pipeline • Relief valve stuck or mis-set	• Thaw and insulate exposed piping • Verify relief valve setting/condition
Chemical Leaks	• Loose fittings • Cracked piping • Worn diaphragm • Damaged O-rings/gaskets	• Tighten fittings • Replace damaged piping • Install new diaphragm • Replace gasket/O-ring set
Inaccurate Feed Rate	• Calibration drift • Viscosity changes • Worn pump components • Blocked calibration column	• Recalibrate pump • Verify chemical temperature/viscosity • Inspect and rebuild pump head • Clean calibration column
Pump(s) Will Not Reach Expected Pressure	• Worn valves or diaphragm • Air entrainment • Relief valve lifting prematurely	• Replace valve assemblies • Eliminate air upstream • Check PRV setting
Suction Line Air Intrusion	• Cracked tubing • Loose joints • Worn foot valve • Porous hose or fittings	• Replace damaged suction components • Tighten all joints • Replace foot valve
Foot Valve or Strainer Issues	• High debris loading • Chemical precipitation • Screen plugging	• Clean or replace foot valve assembly • Evaluate upstream filtration
Diaphragm Failure Symptoms	• Loss of flow • No discharge pressure	• Replace diaphragm immediately • Inspect pump for secondary damage
VFD / Electrical Problems	• Incorrect settings • Low voltage • Wiring errors • Fault codes present	• Refer to OEM manual for VFD • Confirm rated supply voltage • Reset drive if appropriate • Correct wiring per diagram
Mixer Not Operating Properly	• Motor fault • Bent shaft / loose propeller • Worn bearings • Electrical failure	• Inspect motor and wiring • Verify alignment and connection • Replace bearings/shaft as needed
Alarms or Level Switch Issues	• Improper setpoint • Faulty float switch • Wiring/connection problems	• Adjust setpoint • Test and replace float switch • Resolve wiring issues

SECTION 4 — WARRANTY / LEGAL RESPONSIBILITIES

4.1 General Responsibility Assignment

Madden Engineered Products manufactures engineered chemical feed system equipment. The performance, lifecycle, and operating behavior of this equipment is strongly influenced by the environment in which it is installed, including but not limited to: water treatment program, operator technique, DCS/PLC control design, field piping method, outside pipe routing, and facility utility balance.

Therefore:

- The owner / facility is responsible for ensuring the system is installed correctly and operated under normal industrial conditions. Owner shall ensure compliance with local environmental regulations.
- The installer / piping contractor is responsible for correct piping practices, valve selection, vent routing, support, and service access.
- The local water treatment / chemical supply vendor is responsible for determining the correct chemical dosing rate.
- The water treatment provider is responsible for correct chemical control, conductivity strategy, scaling / corrosion mitigation, and general treatment philosophy.

Madden provides mechanical equipment. Madden cannot assume operational control or data-driven decision responsibilities for the user's chemical treatment process.

Improper field modifications (including unapproved ancillary equipment, valve substitutions, system piping changes, gauge or probe modifications, or drilling / welding) void warranty.

4.2 Warranty Terms

Except where a different express warranty has been issued in writing for a specific product or project, no warranty of any kind, express or implied, is extended by Madden Engineered Products (Seller) to any party other than the direct purchasing Buyer.

To direct Buyers only, Madden warrants that it will either (at Seller's option):

- Furnish replacement parts freight allowed to the initial domestic destination, OR
- Repair the component

For any item manufactured by Madden which is proven to Madden's satisfaction to be defective in material or workmanship under normal use and service:

- within 18 months from date of shipment, or
- within 12 months from the date the equipment is first placed in use

These terms apply only to Madden equipment manufactured at our Elkhart, Indiana facility.

Ancillary purchased components from outside suppliers are covered only by those manufacturer's original warranty terms (see "Goods of Other Manufacturers" below).

Madden assumes no responsibility for:

- Performance under conditions materially different than normally tested
- Damage due to abrasion, erosion, corrosion, scaling, abnormal thermal cycling, or foreign debris
- Damage caused by oversized or pulsed blowdown events outside normal surface blowdown range
- Any labor cost, field removal, installation, rigging, or troubleshooting cost
- Any freight beyond the original domestic destination
- Any substitution of non-Madden parts or unauthorized modification

The Seller shall not be liable for any cost, loss, or consequential damages beyond the price of goods sold.

Goods of Other Manufacturers: Components sourced outside Madden are not warranted by Madden directly. Madden will make good faith effort to assist Buyer in securing remedies available from the component OEM.

This warranty is in lieu of all other warranties expressed or implied, including merchantability or fitness for a particular purpose.

SECTION 5 — APPENDICES

Reminder, for any chemical feed system order, Madden provides system specific literature for review and approval before fabrication. Contact our factory or your company's purchaser / project manager / or in-house engineer for most of these details.

- Appendix A — System P&ID (Provided Separately During Submittal Review)
- Appendix B — General Arrangement Drawings (Provided Separately During Submittal Review)
- Appendix C — Specific Component Operator's Manuals (Provided Separately During Submittal Review)
- Appendix D — Electrical Drawings (Provided Separately During Submittal Review)
- Appendix E — Factory Testing Data (Provided Separately After Fabrication)