INSTRUCTION MANUAL

FOR

Model L Pilot Plant

CUSTOMER CONTRACT NO.: 131615

NIRO CONTRACT NO.: 9999-B287

PRODUCT: Various

DATE: May 2007

These instructions are provided for your convenience and safety when operating, servicing and maintaining the plant equipment.

Please read all instructions carefully. Failure to follow all instructions may result in equipment damage, personnel injury and/or production loss.
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All plant personnel must be familiar with these instructions. NIRO will not assume any responsibility for personal injury or equipment damage caused by faulty operation.
1.1 **Design Basis**

The GEA Filtration Model L Pilot Plant is a small-scale system for testing various membrane filtration processes up to 1000 psig (70 bar). It is an excellent research/development tool for membrane filtration, namely reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF).

The Model L Pilot Plant is a complete unit ready for immediate operation. It is mounted on a cart with casters for mobility. It is designed to perform batch tests on product volumes ranging from 2 to 25 gallons (typical).

The Model L Pilot Plant has the following features:

- Small footprint and cart mounted on wheels for ease of transport
- Feed tank
- Heat exchanger
- All necessary gauges and valves
- Flat sheet membrane test module
- Spiral membrane test module
- Options to add all types of polymeric and inorganic membrane modules, (tubular, hollow fiber, capillary)

The base system incorporates the plate and frame Lab Module M20 with 7.8 sq ft. (0.72 sqm) of membrane area. The Lab Module M20 accepts flat sheet polymeric membranes of all types. It has the unique feature of being able to simultaneously screen a number of flat sheet membranes. The Lab 20 module can accept as few as 4 flat sheets to as many as 40 sheets. This flexibility allows the module to run anywhere from 1 to 8 gallons per hour.

A spiral membrane pressure vessel, 2.5 inch diameter by 40 inch length, is included for testing spiral elements at both low and high pressure. A ceramic membrane module for testing lab scale ceramic MF or UF elements is included as well.
1.2 Specifications

The GEA Filtration Model L Pilot Plant consists of:

1 **Tank**

   Tank, 4 gallons capacity. The tank is fitted with a manual shut off valve and is connected to the pump. All product contact area is made of 316 stainless steel and finished to 150 grit polish.

1 **Pump**

   The feed pump is a Wanner D10 high-pressure positive displacement pump with a capacity of 8 gpm (1.8 m³/hr) and maximum outlet pressure of 1000 psi (70 bar). The pump is driven by a 7½ hp, 230 volt, 1750 rpm, 3 phase, variable speed motor. All product contact area is 316 stainless steel.

1 **Heat Exchanger**

   The heat exchanger is mounted on the inlet to the module to cool the liquid prior to entering the module. This is required to remove the heat energy generated by the recirculating liquid.

   Heat transfer area is 0.82 sq ft. (0.076 sqm)

   The heat exchanger can be used for heating also.

4 **Pressure Gauges**

   (2) WIKA 0 - 145 psi (10 bar) and (2) 0 - 1450 psi (100 bar) gauges to monitor plant pressure.

1 **Temperature Gauge**

   (1) Bi-metal, Tel-Tru 20 – 240degF (110 degC) range to monitor plant temperature.

1 **Lab-Module M 20**

   The Lab-Module has a membrane area of 7.9 sq ft. (0.72 sqm). The module is equipped with polysulfone membrane support and spacer plates. The module can operate at a pressure of up to 1000 psi (80 bar), pH 0-14 and temperature up to 212 degF (100 degC). The membrane
used in the module may be less resistant and thereby set operating limits.

Each membrane support plate is provided with a small outlet to collect the permeate individually which allows for simultaneous testing of multiple flat sheet membranes.

The module base is a built-in hydraulic cylinder, activated by hand operated hydraulic pump, to be able to compress the module after mounting the membranes.

1 Pressure Regulating Valve

The module pressure can be regulated by the spring-loaded valve. It functions as a safety valve for the feed pump.

1 2540 Membrane Vessel

The housing is 2.5” in diameter and 40” long. The housing is rated up to 1000 psig. The housing is 316SS.

1 Ceramic Housing

316 stainless steel, for testing 10mm diameter by 250 mm length ceramic elements.
1.3  *Process Description and Plant Operation*

**Water Quality Specifications**

Water used for flushing, cleaning and disinfection of Model L plants must conform to the following standards to obtain the best possible results.

It is a prerequisite that the following standards be adhered to for membrane guarantee to be valid. It is also recommended that the water be analyzed at least every three months to ensure proper quality. If the water quality does not meet these standards, consult a Niro Inc. representative.

<table>
<thead>
<tr>
<th></th>
<th>Less than 0.05 ppm</th>
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<tbody>
<tr>
<td>Iron (Fe)</td>
<td></td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>Less than 0.02 ppm</td>
</tr>
<tr>
<td>Silicate (SiO$_2$)</td>
<td>Less than 10 ppm</td>
</tr>
<tr>
<td>Aluminum (Al)</td>
<td>Less than 1 ppm</td>
</tr>
<tr>
<td>Hardness as CaCO$_3$</td>
<td>Less than 10 gr/gal (170 ppm)</td>
</tr>
<tr>
<td>Particles</td>
<td>Less than 25 microns</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Less than 1 NTU</td>
</tr>
<tr>
<td>Silt Density Index (SDI)</td>
<td>Less than 3</td>
</tr>
<tr>
<td>Total Plate Count</td>
<td>Less than 1000 per ml</td>
</tr>
<tr>
<td>Coli Count</td>
<td>0 per 100 ml</td>
</tr>
<tr>
<td>Chlorine</td>
<td>Undetectable</td>
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Any deviation from the above may influence the performance of the plant.
**Terminal Points**

Customer is responsible for supplying facilities to and from the plant as follows:

**Product:** To the inlet of the feed inlet valve or to the feed tank

**Concentrate:** From the outlet of the concentrate hose

**Permeate:** From the outlet of the permeate outlet hose

**CIP Water:** To the inlet of the feed inlet valve or to the feed tank

**Cooling Water:** To and from heat exchanger.

**Electrical:** Power to the pump
INTRODUCTION

The intention of the following discussion is to familiarize and introduce the reader to membrane filtration/separation at an introductory level.

Membrane filtration, as we discuss, has been used and known of for many years, but only more recently has been used on a commercial scale successfully. This is due to recent introductions of membrane materials and construction methods. Before the 1970's, the membrane material was sensitive to the most commonly used cleaning chemicals and procedures and thus difficult to clean. The materials during the 1970's and 1980's have progressed to the point where membrane cleaning is typically not a problem if certain guidelines are followed. Systems are thus found in many different types of industries such as dairy and food, pharmaceutical and biotech.

Another advance, which is equally if not more important, is the method of construction. Today, most all membranes are of the asymmetric design, which is referred to as spiral. This construction method results in a much greater membrane area with equal energy consumption, cleaning chemical use and floor space than the designs, which it replaced, such as plate and frame.

Ceramic membranes have also evolved during the 1980's and have become a major player in the Microfiltration area.

DEFINITIONS

Before the discussion goes too far, it would be helpful to define a few terms, which are often times used in the membrane filtration field. By no means do we wish to include all related terms, but just a few which are pertinent to the discussion and to the successful operation of the NIRO system.

A.T.D. (Anti-telescoping device)

The device is located on the downstream end of the spiral element to prevent the leaves from telescoping or being pushed downstream. Often times the A.T.D. and interconnector are built as one.

B.O.D. (Biological Oxygen Demand)

Generally expressed as BOD₅, this is the quantity of oxygen required to decompose organic material, expressed as parts per million (PPM).
BACK PRESSURE

The system operating pressure which is measured at the concentrate end of the element.

BACK PRESSURE VALVE

The valve which the concentrate is throttled through. Often times referred to as the concentrate flow control valve.

BOOSTER PUMP

See recirculation pump.

CENTER TUBE

See permeate tube.

CONCENTRATE

See retentate.

CONDUCTIVITY

Used as an approximate measurement of mineral content. Units commonly used as micro mhos/cm.

ELEMENT

Often times referred to as membrane. Can be used interchangeably. This refers to the filtration material that fits inside the pressure vessel.

FLUX

Permeate flow through a membrane. Generally calculated as liters/m²/hour (lmh).

FOULING

Refers to the flux decline of an element.

INTERCONNECTOR

This device connects two spiral elements together or an element to the permeate end cap.
MEMBRANE

Term used to refer to the semi-permeable material by which the separation process takes place.

MEMBRANE CUTOFF

Term used to describe the molecular weight size, which becomes too large to pass through a specific membrane. The molecules, which are larger than the cutoff will be retained or rejected whereas the smaller ones will pass through (permeate). Could be an absolute or nominal cutoff.

MODULE

A device which contains the elements, such as a ceramic module or plate and frame module.

PERMEATE

The material which passes through the membrane.

PERMEATE END CAP

This device is generally located on the downstream end, but not always, of the vessel and the permeate exits through it.

PERMEATE TUBE

A tube at the center of a spiral wound element of which the permeate flows into and thus exists the element. The interconnector also connects into this. Sometimes referred to as the center tube.

RECIRCULATING PUMP

Sometimes called a booster pump. In a recirculation loop the pump is necessary for creating an optimum cross flow across the membrane surface.

RECOVERY

Generally described as a percentage. Used with reverse osmosis systems. Calculated as the permeate flow rate divided by the feed flow rate and multiplied by 100.
REJECTION

Generally described as a percentage of salt rejection in a reverse osmosis membrane. Calculated as the percentage of salt which is held back by the membrane. \( R = 1 - (C_p/C_b) \), where

\[
\begin{align*}
R & \quad = \text{Rejection} \\
C_p & \quad = \text{concentration in permeate} \\
C_b & \quad = \text{concentration in retentate}
\end{align*}
\]

RETENTATE

Often times called the concentrate. This material is held back by the membrane and is thus concentrated.

VESSEL

Often times called the pressure vessel. This tube contains the spiral element inside it.

PROCESS

Generally, the process of separation takes place across a semi-permeable membrane. A pressure gradient is required to perform the separation. The type of filtration we are discussing involves a pump(s), which creates this gradient. Thus, the pressure difference will cause a separation of different size particles or molecules to take place. The determination of what molecules pass is dependent on the membrane itself.

There are generally four different types of filtration, which Niro deals with. These are Microfiltration, Ultrafiltration, Nanofiltration and reverse osmosis. Often times, Microfiltration and Ultrafiltration are discussed together as well as Nanofiltration and reverse osmosis together.
MICROFILTRATION AND ULTRAFILTRATION

Microfiltration and Ultrafiltration (MF & UF) are separation processes, which use a membrane that is more open than say reverse osmosis. Molecules such as salts and sugars will pass through (permeate) where as the larger molecules such as proteins will be retained. Figure 1 shows this schematically.

Note figure 1 where MF and UF are shown in relation to other separation processes. In the processes of MF and UF, the macromolecules are being separated. Since this is the case, there is negligible osmotic pressure between the permeate and concentrate (osmotic pressure will be discussed further with reverse osmosis). Since osmotic pressure does not play a part in the process, the separation will take place at pressures less than 10 bar (145 psi).

Typical Microfiltration processes might be chemical reclaim, salt brine clarification, dextrose clarification, etc. An example of using the Ultrafiltration process would be production of whey protein concentrate.

NANOFILTRATION AND REVERSE OSMOSIS

Nanofiltration and reverse osmosis (NF & RO) are separation processes, which use a membrane where the pore size is so fine that only water and similar small molecules can pass through. With NF, dissolved salts will pass, but with RO even the salts will not pass or will pass very slowly.

Figure 3 shows an RO schematically. The permeate contains pure water and a small amount of pure salts.

A typical NF process is one where all the proteins and sugars are retained but where the water and dissolved salts will pass through the membrane. An example would be desalting of whey.

A typical RO process would be used in concentrating whey where only water is removed. Another could be “polishing” water where the impurities are concentrated and the permeate becomes a more pure water than the feed. The amount of salt, which passes through a membrane, depends of the membrane type as well as temperature and pressure. The “tightest” membranes are called “sea water” and have a salt rejection of not less than 98%. A “brackish water” membrane will have a salt rejection of not less than 96%. Most of the RO processes, which Niro is involved in, use the brackish water element.

For NF and RO to operate, the pressure difference must overcome the osmotic pressure. The osmotic pressure varies depending on the solutions being separated. For whey concentration the designed operation pressure is typically 30 (bar) (435 psi)
Osmosis occurs when a membrane, which only allows water to pass through, separates two salt solutions of different concentrations. Because of the difference in concentrations, equalization will take place between the two solutions. Water will pass through the membrane from the least concentrated to the most concentrated solution.

As seen in figure 4, the volumes on each side of the membrane are equal at the start. However, after equalization, the water level will be lower due to the transfer of water to dilute the more concentrated side. The level difference will make a hydrostatic pressure, which will counteract the transfer of the water and thus stop the transfer. This difference is called the “osmotic pressure”. See figure 5.

If an external pressure larger than the osmotic pressure is applied to the more concentrated side, water will pass the opposite way through the membrane and concentrate the salt solution further (figure 6). This in effect is what reverse osmosis does. It overcomes the osmotic pressure of the concentrated material and thus pushes water through the membrane. If this external pressure were to end, then the water again would pass back and dilute the salt solution.
PRINCIPLE OF ULTRAFILTRATION

PRESSURE

FEED

PERMEATE

MEMBRANE

WATER

SMALL MOLECULES SUCH AS SUGARS AND SALTS

LARGE MOLECULES SUCH AS PROTEINS

FIGURE 1
FILTRATION SPECTRUM

RANGES OF FILTRATION PROCESSES

MEMBRANE TYPE

ULTRAFILTRATION

CLOTH & DEPTH FILTERS

SCREENS & STRainers

RELATIVE SIZE OF COMMON MATERIALS

NANO FILTRATION

LATEX EMULSIONS

METAL IONS

OIL EMULSIONS

AQUEOUS SALTS

RED BLOOD CELLS

ATOMIC RADI

PAINT PIGMENT

CARBON BLACK

BACTERIA

PYROGEN

YEAST CELLS

MYCOPLASM

SAND

PROTEINS / ENZYMES

HUMAN HAIR

PARTICLE SIZE (Microns) 10^-4 10^-3 10^-2 10^-1 1.0 10 10^2 10^3

PARTICLE SIZE (Angstroms) 1 10 100 1000 10,000 10,000 10^6 10^7

APPROXIMATE MOLECULAR WEIGHT

100 200 20,000 50,000

ELECTRON MICROSCOPY

OPTICAL MICROSCOPY

VISIBLE TO NAKED EYE

Figure 2
PRINCIPLE OF REVERSE OSMOSIS

FEED

PERMEATE

PRESSURE

MEMBRANE

WATER

• SMALL MOLECULES SUCH AS SUGARS AND SALTS

• LARGE MOLECULES SUCH AS PROTEINS

FIGURE 3
OSMOTIC PRESSURE
EXAMPLE:
IMMEDIATELY AFTER
POURING EQUAL VOLUMES
TO EACH SIDE

FIGURE 4
OSMOTIC PRESSURE EXAMPLE:
AFTER EQUALIZATION

FIGURE 5
1.5  **Material Safety Data Sheet**

GEA Filtration has provided a few links to MSDS sheets for a variety of membrane preservatives and CIP chemicals.

The customer is ultimately responsible for obtaining and maintaining MSDS sheets for all chemicals located in the plant as required by all state and local laws.

- **Ecolab CIP Chemicals**
- **Koch Membrane Preservative**
- **PTI Membrane Preservative**
- **Filmtec Membrane Preservative**
1.6 *Process and Instrumentation Drawings*

9999-B287 Model L Pilot Plant (PDF)
1.7  Arrangement Drawings
1.8  Tag List

9999-B287 Tag List (Excel)

9999-B287 Tag List (PDF)
1.9  **Motor List**

9999-B287 Motor List (Excel)

9999-B287 Motor List (PDF)
SECTION 2 - OPERATION

OPERATION

All plant personnel must be familiar with these instructions. NIRO will not assume any responsibility for personal injury or equipment damage caused by faulty operation.
2.1 **Pre Start-Up Procedure**

**Note:** Check all pumps for proper oil level and check routinely. Many pumps are shipped without oil, and must be filled to proper level before starting.

1. Wheel unit to its test location. Use the wheel locks to prevent the unit from rolling unintentionally.
2. Ensure all services are available to the plant by turning on or opening the valve.
   - Power to all pumps
   - Clean water supply for CIP
   - Cooling water
   - Product supply
3. Make all inlet and outlet line connections. These were not supplied.
4. Make sure all valves are functional, and in the correct position.
5. Make sure operator is familiar with all the functions of the system.
   Please review section 6-10 Controls.
6. Determine if you will perform a pilot test using Reverse Osmosis / Nanofiltration or Ultrafiltration / Microfiltration.

   For RO or NF you will need to install the 1450 psi pressure gauges, the high pressure clamps and the high pressure valve spring.

   For UF or MF you will need to install the 145 psi pressure gauges, you can use either high pressure or low pressure clamps and install the low pressure back pressure valve spring.
2.2 **Start-Up Procedure and Operation**

Please refer to the Wanner and Baldor manual for running the Feed Pump. Once the motor is running the speed can be increased or decreased by simply pressing the up arrow (to increase speed) or the down arrow (to decrease speed) located on the control panel.

For setup and operation and the running of products through the membrane units please refer to the manufacturers manuals. An extensive manual on the DSS LabStack M20 is included in Section 7 of this manual. Also, for the running of spiral or other types of membranes in the 2.5” vessel it is important that the operator be aware of any restriction (temperature, pressure, chemical concentrations, etc) that the specific elements may have.
Recirculation

The Recirculation step is typically used just prior to Production, During CIP, or possibly during Production if there is a short interruption while running on product.

1. Ensure all system outlet lines are directed to return to the feed tank.

2. Ensure drain valve (HV-3402) is closed.

3. Ensure that all piping connections are in place with proper clamps for desired filtration.

4. Install desired pressure relief spring into pressure relief valve (PSV3501). Springs were provided for low (yellow spring, 350-750 psi) and high (purple spring, 750-1500 psi) pressure applications. Install spring and set to desired cracking pressure.

5. Fill the feed tank with De-chlorinated water.

6. Set concentrate control valve HCV-3014 at approximately 90% open. If operating with Scepter module, completely close Permeate flow control valve HV-3014.

7. Start the Feed pump by pressing the start button on the control panel. The feed pump should start out running at a very low speed.

8. Continue to operate the system in this manner until the system is free of entrapped air. (A good indication of the system is free of air is when air bubbles are no longer being released from the concentrate or permeate lines in the feed tank.)

9. Adjust speed of feed pump using the up and down arrows on the variable speed drive and slowly close the Concentrate flow control valve HV-3014 to get the desired recirculation flow rate and baseline pressure. The feed pump should be the main adjustment to get the desired flow into the system. As you close the Concentrate flow control valve HV-3014 you will see a corresponding drop in flow and a rise in pressure.

10. Slowly open the permeate flow control valve for Scepter applications HV-3016. Open valve 1 to 2 psi increments. Let system run for 15 seconds. Open valve again an additional 1 to 2 psi, wait 15 seconds. Continue to open valve and wait 15 seconds as described above until you reach desired recirculation permeate back pressure.

11. Open the cooling control supply and return valves (customer supply) and set cooling supply flow to reach the desired recirculation temperature.
12. The system is ready for another mode of operation. Please see headings for Production, CIP, or Flush.

13. Press the stop button on the control panel to stop the Feed pump.

**NOTE:** Several adjustments to the pump drive controller may be necessary to obtain the ideal condition. Typically Recirculation is run at pressures approximately 100 psi for RO or NF applications and 15 psi for UF, MF, or Scepter applications. When running the Scepter module, the baseline pressure should always exceed the permeate back pressure.

**CAUTION:** The plant is in recirculation and can run in this mode indefinitely provided the temperature does not exceed recommended high temperature limits by the membrane supplier. The system is equipped with a cooling heat exchanger and should be used when running in recirculation mode or CIP. Consult the membrane supplier for temperature limitations.

**CAUTION:** *Never shut down the system with product in it without doing a full CIP except in an emergency situation. Many feed materials become very difficult to clean and remove once they have cooled to room temperature.*
**Production**

1. Start system in recirculation

2. Connect the feed supply to feed supply inlet or fill feed tank.

3. Make down stream processing connections and drain line connections and secure clamps.

4. Adjust the speed of feed pump using the variable speed drive and slowly close the Concentrate flow control valve HV-3014 to get the desired production flow rate and baseline pressure. The feed pump should be the main adjustment to get the desired flow into the system. As you close the Concentrate flow control valve HV-3014 you will see a corresponding drop in flow and a rise in pressure.

5. Adjust permeate back pressure valve for Scepter applications (HV-3016) as you would for Recirculation. Open valve in 1 to 2 psi increments and let system run for 15 seconds. Open valve again an additional 1 to 2 psi, wait 15 seconds. Continue to open valve and wait 15 seconds as described above until you reach desired production permeate back pressure.

**NOTE:** Several adjustments between the pump speed and the flow control valve (HV-3014) may be necessary to obtain the ideal condition for the process application. Typically Spiral membrane applications are run at feed pressures 100 to 800 psi. Typical Scepter applications are run at feed pressures between 0-40 psi and permeate pressures of 0-20 psi. When running the Scepter module, the baseline pressure should always exceed the permeate back pressure.

**CAUTION:** The system is not set up to provide automatic shut-down for high plant pressures or temperatures. Please refer to membrane manufactures manuals to determine proper operating ranges.

**NOTE:** The system can run in Production until the feed supply is completed or a CIP becomes necessary due to low flow (25% membrane flux drop) or high loop pressure differential (40 psi). Any time there is a shut down for more than a few minutes, or a change in the feed source, the system should under go a full CIP.

**CAUTION:** *Never shut down the system with product in it without doing a full CIP except in an emergency situation. Many feed materials become very difficult to clean and remove once they have cooled to room temperature.*
6. Stop the Feed pump by pressing the stop button on the variable speed drive.
2.3 **Flush**

This step is used after Production and every CIP step.

1. Stop feed supply coming to system.
2. Connect the CIP water supply to system.
3. Set the system to run as it would in recirculation with the exception of running the Permeate and Concentrate lines to the drain.
4. Run the system as you would in recirculation procedure.
5. As the tank level drops CIP water will flow into the feed tank and flush out the system.

**NOTE:** It will be necessary to flush the membranes out with the feed pump running above 50% and HV-3014 nearly fully open. This will ensure that a high flow rate is passing over the membrane surface for cleaning purposes.

6. Once the water exiting the drain line becomes clean and pH neutral you can discontinue the flush and return the Permeate and Concentrate lines to the feed tank and prepare for CIP.
2.4 *Emergency Shutdown*

In an emergency, do not worry about the pressure. Just select the stop button on the feed pump.
2.5 Cleaning

This step must be completed after any time in which the membranes have been exposed to product or when they are newly installed.

Since CIP is entirely process dependant, the procedure will vary with the type of membrane installed and the type of process being run.

1. Start up system in recirculation

2. Ensure the CIP supply is at the proper temperature.

Set the cooling water supply to the heat exchanger to maintain CIP temperature required by the membrane manufacturer. Monitor at temperature gauge TI3016.

3. Ensure the cooling/heating control supply to the system is on.

4. Ensure the Permeate and Concentrate lines are returning to the feed tank.

5. When the system is at proper temperature add chemical to the feed tank and check pH to ensure effectiveness of the cleaning.

6. Record CIP data found on the CIP cleaning log sheet found in section 3.3 of this manual.

7. Each wash step should be followed by a flush step as outlined in the section 2.3 titled “Flush”.

8. After the final CIP flush a clean water flux test should be done to determine if the CIP was successful. To perform a flux test the operator must record the feed temperature, the feed line pressure and the permeate flux. The flux numbers should be compared to the previous cleaning log sheets to confirm that the flux is similar. If the permeate flux is 15% lower than the previous flux test, an additional cleaning should be performed. Clean water flux excel spreadsheets can be found in section 3.4 of this manual.

9. If the system is going to sit idle for more than 6 hours, the spiral membranes and Scepter module should be removed and stored as described in section 2.8.
**CIP**

Proper CIP of the system is critical to the operation of the Model L. While not terribly difficult, proper attention to detail is a must. Specified pH’s and temperatures are required and inflexible. Due to the nature of membranes, chemical strength is limited, and thus efficiency must be maximized. Maintain pH’s where instructed, use the specified amount of chemical, and complete the log sheets daily.

System CIP is manual. When CIP temperature setpoints have been reached, chemicals can then be added. CIP profiles need to be set up according to the CIP procedures specified by the membrane manufacturer.

While RO/NF elements are intolerant of oxidizers such as chlorine or peroxide, UF elements will use some chlorine with the caustic wash step to increase the efficacy of the caustic. The absolute limit for UF membranes is 200 ppm chlorine and the wash procedures are limited to 150 – 180 ppm. *Always add the caustic to the system before adding chlorine!*

As with the RO/NF elements, these elements are also intolerant of any silica-based defoamers, even those labeled for food grade use. *Use of defoamers will result in permanent flux loss and void membrane warranty!*
2.6 *Trouble Shooting/Alarms*

No alarms were provided by Niro.
2.7  *Daily Production Log Sheet*

**Production Log Sheet Template**

The production log sheets must be filled out at a minimum every hour and kept on file.

Please note that a Niro service technician may request copies of your production log sheet at any time. If they are not complete, the membrane warranty may be void.
2.8 Membrane Preservation

If the system is to be down for an extended length of time, the membranes should be stored in a preservative. The normal preservative will be a 0.5 to 1-percent solution of Ultrasil MP. Add enough preservative to get a pH of 3 to 4. The solution should be circulated every 3 to 4 days and flushed once a week. If a new solution is required, a caustic wash should precede the addition of fresh preservative.

The Scepter module should be fully CIPed and removed from the system to dry if it will not be used for an extended length of time.
2.9 **Analysis Methods**

- Filterable Solids for Cheese Whey
- Suspended Solids in Whey
- Free Air in Whey
- Protein
- Milk Fat
- Salt Rejection RO
- Suspended Solids Corn Syrup
- MgSO4 Rejection for NF
- Silt Density Index
2.10 Membrane Performance Tests

Membrane Leak Detection
2.11 Other Operations

MEMBRANE LOADING INSTRUCTIONS
SECTION 3 – CLEANING & DISINFECTION

CLEANING AND DISINFECTION
3.1 **Declaration**

Cleaning and disinfecting of your membrane filtration plant is a very critical operation.

Please read all cleaning instructions and information fully and **understand** them. Failure to follow all instructions may result in irreversible damage to the membranes.

For warranty purposes, only the cleaning procedure that Niro approves in writing may be used. It is the customers' responsibility to inform Niro of any cleaning procedure changes before implementing them. Niro must approve any changes in advance. Niro will not assume any responsibility for damaged membranes if the above is not followed.
3.2 **Cleaning Procedure and Chemicals**

The CIP procedure recommended has been optimized to remove fouling and sanitize the membrane and associated hardware surfaces while minimizing membrane degradation. The cleaning agents used are compatible with the membrane and should never be substituted for, or used in concentrations outside the limits, without prior approval from NIRO.

By strictly adhering to these recommendations, the processor can maximize the life of the membranes and thus maximize the return on investment.

**Cleaning and Basic Chemical Requirements**

The cleaning sequence has four primary objectives:

- Removal of a flux-inhibiting layer on the membrane surface.
- Removal of precipitated small molecular weight substances (salts, carbohydrates) from within the membrane structure.
- Sanitation of the system for prevention of microbial growth, if required.
- Cleaning of associated hardware and pipe work.

To meet these criteria, an acceptable cleaning cycle consists of:

- Proper cleaning chemicals for removal of soil and membrane fouling species. Cleaning solutions must be approved by Niro to prevent damage to membranes by incompatible chemicals.
- Adequate fluid flow rates to provide physical cleaning of surfaces.
- Adequate time for exposure of cleaning solutions.
- Proper temperature for exposure of cleaning solutions.
- Adequate flushing procedures to prevent mixing of chemicals.
- An acceptable monitoring program to insure that the cleaning cycle is properly performed by plant operators.
3.3 *Cleaning Log Sheet*

**CIP Log Sheet Template**

The following cleaning log sheet must be filled out in full during every cleaning step. Absolutely every step the operator does during the cleaning must be logged.

Please note that a Niro service technician may request copies of your cleaning logs. If they are not complete, the membrane warranty may be void.

A daily water flux log is part of the cleaning log sheet. It is your responsibility to record the permeate flux everyday after cleaning. This aids Niro in trouble shooting performance problems.

Instructions for obtaining the fluxes are located in Section 2.5. If you are unsure of the procedure, please contact Niro for further assistance.

Please note that for consistent data, the flux must be checked at the same temperature and pressure everyday. The temperature and pressure should be recorded on the log sheet.
3.4 Clean Water Flux Program

FLUX TEMPLATE LINK
3.5 Cleaning Theory

THE CHEMISTRY OF MEMBRANE CLEANING

The use of membranes in many fields (food industry, water treatment, pharmaceuticals, biotechnology, and industrial waste treatment) is on the increase. As more and more applications are found, more and more membrane systems are devised, thus, the difficulties in cleaning these plants increase and become more complex. We know that regulatory agencies such as FDA, USDA etc. are getting more involved by the day in inspection of new technologies and processes, and membrane filtration is one of them.

What is so different about membrane cleaning as compared to tank cleaning or evaporator or tankers? In most processing or engineering fields, the material we encounter is metal, stainless steel or maybe sophisticated, complex blends of alloys and the like. Membranes for the most part are made of different material and because of the manufacturing process, the particular characteristics, membranes are simply much more expensive per unit area than normal material. When damaged, they cannot be repaired, they have to be replaced at great cost. They are much more fragile and more sensitive to all sorts of influences.

Ecolab, having been involved in the cleaning of membranes from the beginning of their introduction into the food processing field, thought that in view of the many inquiries coming from the membrane manufacturers and users alike, a session on theoretical and practical aspects of membrane cleaning would allow us to clear up some important points. While membrane cleaning is different, it is not necessarily difficult or scary.

There are many membrane filtration systems in use today. It is not our purpose to list them all, to explain their differences, advantages or disadvantages. The literature available by most of the manufacturers will provide some idea of new developments. We must define a few basic terms as a starting point of our discussion.

Filtration techniques can be classified according to the molecular or particle size that is separated.

Microfiltration, also called cross flow filtration is in the range of 1/100 to 1/10,000 of a millimeter. Small particles, living cells, i.e. bacteria and large colloids fall into this category.

Ultrafiltration goes beyond the particle size. Here we filter molecules, which are dissolved in solution (it may be a perfectly clear solution with no visible cloudiness). Those molecules are called MACROMOLECULES; they are usually long chains composed of smaller links (protein, starch, and oily substances). Smaller molecules such as sugar, salts, etc., go through a UF membrane. UF membranes are pore-membranes with transition paths of varying size, thereby effectively selecting different molecular sizes.
Reverse Osmosis is the technique (also called hyperfiltration) where practically nothing but the solvent, i.e. water, goes through the membrane. All dissolved substances remain on the concentrate side.

A somewhat different process designed to remove ions, (charged molecules or atoms from a solution) is called Electrodialysis. There the combined effects of electrical field and membrane selectivity are used in the separation.

Membrane separations, independent of the size of the entities to be separated, can also be classified according to the design of the modules holding the membranes. Again, please always refer to the manufacturer’s literature for details. There are many different types, each with advantages and disadvantages. Plate and spacer modules assembled like a plate heat exchanger, spiral wound modules, hollow fiber modules and tubular modules reminiscent of tubular heat exchangers, are the most common ones.

Still another way of categorizing membranes is by the composition material. It all started with cellulose acetate and derivatives, and then synthetic polymeric membranes appeared, made of polysulfone, polyamide, polycarbonate, polyacrylate and many more. Then there are the non-polymeric, inorganic membranes made of carbon with an active layer of zirconium oxide and lately the aluminum oxide membranes.

One of the most important items to consider when talking about cleaning is the particular application of the membranes. The fouling (soiling of the membrane during process) plays a major role in the success of the cleaning procedure. Membranes are used to filter:

- cells in biotechnology
- valuable drugs in pharmaceutical industry
- alcohol in making alcohol free beer
- orange and other fruit juices
- blood
- kraft fluids
- oil emulsions
- waste water
- liquid egg preparations
- salt water and many others

The term sanitation is somewhat unclear and vague. Sometimes it is used to mean cleaning and sanitizing together, as a sort of general expression. Sometimes it means the specific step of using a sanitizer to kill bacteria and other microorganisms. We will concentrate on cleaning, the removal of oil in this section. Sanitizing will be discussed separately later.
When we consider the different possibilities of combining the elements previously mentioned: membrane material, module type, filtration technique, and soil composition, then we come up with a staggering number. Of course, not all combinations are found in practice, but quite a few of them are real. For each type of soil on each membrane on different modules one might need a different cleaning procedure. Cleaning is not a science, although it might merit being one, it is so complex. Membrane cleaning is more an ART than a science due to the variables.

Consider the traditional four factors of important in cleaning:

Time
Temperature
Mechanical Action (Energy)
Concentration (Chemistry)

For membrane cleaning we must go into more detail and add a few items. The water used for cleaning, the membrane material, the module design and the soil have to be considered. We will discuss each item separately.

TEMPERATURE:

An increase in temperature leads to an increase in the speed of chemical reactions, doubling them for every increase of 18° F. This is of course an approximation valid only within certain limits and under ideal conditions. But it is true that cleaning is more efficient at higher temperatures. In an alkaline cleaner, the hydrolysis of protein speeds up, the solubility of most substances increases, penetration of cleaner into soil accelerates. There is more to temperature when fatty substances are involved. Here the relationship is not as linear as in chemical reaction. A physical phenomenon takes precedence; the melting point. C.I.P. cleaning of greasy surfaces at low temperatures is almost impossible even with the most powerful cleaners unless real solvents are used. However, as soon as the melting range is reached, cleaning becomes easy, so much as that water alone takes care of 95% of the fat removal. The chemistry is needed for the final 5%. This sigmoid curve of fat removal versus temperature is caused by the drastic change in viscosity of the fat film when it melts and to increased surface opens to surfactants when the film spread out.

Once the melting point has been reached, the fat removal is again linearly related to temperature. It would seem logical and profitable to increase the temperature even more to speed up the cleaning process.

However, membrane manufacturers issue very strict limits on the temperature with which the membrane may be treated. They are usually below 140° F, sometimes substantially below. Only the inorganic membranes are an exception to the temperature restrictions. What also compounds the cleaning problem is that when using strong
alkaline cleaners, the temperature allowed is even lower because of the interacting influences of pH and heat.

Flux rate increase with temperature because of the increase in molecular mobility and a certain “widening of the pores.” But if the temperature increases considerably beyond the endurance of the membrane, flux increases are suddenly dramatic and may be irreversible. The retention rate is then compromised and the membrane has to be changed in most cases. As much as it would make cleaning easier sometimes, temperature limits should be strictly observed. Experience has shown though, that in general, cleaning temperatures of 130° F to 140° F are sufficient for most purposes.

MECHANICAL ACTION

The mechanical force or energy put into a cleaning process is of great importance. We realize this when we take the simple case of a glass of milk. When drained and rinsed with water alone, it will not be clean. But take warm water, rub with your fingers and it will look pretty clean. In C.I.P. cleaning this mechanical energy cannot be generated. The speed of flow can be increased; color patterns can be generated that increase the turbulence of the fluid. The Reynolds number is a value, which helps to describe the type of flow in a system. When the Reynolds number is greater than about 2000, turbulent flow sets in. It is clear that we get more action at the interface - surface/cleaning solution.

It is difficult to measure and study the flow patterns inside of modules. One would think that hollow fiber and spiral would modules have no problem generating turbulent flow inside, yet on plate and spacer modules it is not certain that the cleaning solution is turbulent at all stages, everywhere. This could then lead to uneven cleaning results. The design of the modules and the membrane shape itself are very important in this respect. In tubular installations a concept has been used which approaches the mechanical effect of the brush.

Small pellets of cotton were introduced in the tubes and flushed through. The cleaning effect is good but in a big plant it is too time consuming. The effort is not worth it.

The best way to obtain turbulent flow is to increase the speed of flow. Increasing the pump pressure, on the contrary should not do this, pressure should be reduced wherever possible for cleaning. We do not want to filter the solution more than necessary; rather we want to increase the shear forces on the membrane surface. The fouling process dictates the method of cleaning the membrane surface. After a period of time processing (filtering), the fluxes of permeate decrease. The speed of decrease and the amount, depend on many factors:

- product filtered
- temperature and
- total solids to list a few
The decrease in flux is due to the establishment of a layer of solutes, of macromolecules, which accumulate at the membrane surface. The thickness of this layer depends on the flow characteristics and the concentration of the macromolecules in the solution. Higher speed will decrease the thickness, whereas higher pressure may result in temporary increase of flux until a new equilibrium layer thickness has established itself. In cleaning we want to remove this filter “cake” layer. In a conventional filter it could be done by backflushing from the permeate side. In most membrane plants this is not possible because of the fragility of the membrane and because of the asymmetric surface attached to the support material. It is often awkward to design the system for a reversal of flow. One must also ask if it really works. In the case of particle filtration, where pores may really get clogged with individual cells or granules or whatever, a backflush has its justification. In UF and RO the picture may be misleading. Molecules are not small balls. Flushing from the other side will not change the adsorption characteristics of the soil to the surface much.

TIME

Time is the factor everybody wants to save, but if the cleaning time is cut too short the result becomes uncertain, cleaning may be incomplete. On the other hand, it does not make sense to increase the cleaning time indefinitely; nothing is gained by it. It may be detrimental. During cleaning a certain amount of filtering, concentration is going on. Even if we return the permeate to the retentate in the balance tank, diluting the concentrate, soil and detergent solution may deposit on the membrane surface and form a new polarization layer. The cleaning solution becomes saturated after a certain time and cannot continue to remove and hold in suspension any additional solids. Ideally, one should use a cleaning solution for a short while, dump it, flush briefly, prepare a new solution and repeat the process as needed depending on the soil load. If it were not for the chemical cost and the time involved, this would be the best procedure as cleaning results would be excellent. Too long cleaning times are a waste, plus the shorter the time the cleaning solution is in contact with the membrane, the better. Practical experience has shown that in most case 30 minutes for an alkaline wash is sufficient. Only enzyme cleaners may need more than these; hours and even up to days in difficult cases.

SOIL

Any cleaning procedure must take into account the nature of the soil that is to be removed. This is true for stainless steel and even more so for membrane surfaces. Cleaning physics distinguishes between the forces of cohesion and adhesion. In looking at a layer of soil it is clear that the removal of the lop layers is governed by the forces of molecules sticking together. The removal of the last layer, the one adhering to the metal or other surface, is governed by the interaction of soil to surface. In the case of membranes, this interaction is quite complex. There is first the question of electrical
charges, of polarization to consider. When the pH of the cleaning solution is different from the pH of the soil from production, which is often the case, the polarization of the surface changes, there by modifying the adhesion of the soil to the membrane. In the case of inorganic ZrO2 membranes, the polarization follows this curve, whereas on polymeric membranes we obtain a different picture. This will influence soil components of an ionic nature (salts, organic acids, amines) and electrically polarized molecules such as proteins.

A different adsorption occurs for oily, fatty substances. The adhesion to the membrane is then the function of the hydrophilic/hydrophobic balance. Hydrophilic means behavior of a substance which is well soluble in water, miscible with it; hydrophobic is the opposite. Oil is hydrophobic, it will stay on top of a water surface, alcohol is hydrophilic, so is sugar, it dissolves and mixes instantly. Hydrophobic substances attract each other, hydrophilic also tend to stay together. It is no surprise to see those polymeric surfaces such as polysulfones; polyamides and similar types are more difficult to degrease, to clean of fatty deposits than glass or stainless steel. The fatty molecules adhere to hydrophobic polymers stronger than to hydrophilic glass and need more chemical, physical or mechanical energy for removal. Cellulose acetate membranes are more hydrophilic and from this point of view easier to clean than the other membranes were it not for the severe limitation of pH and temperature.

An important consideration is also the viscosity of the soil or its changes of viscosity in contact with cleaners. In membrane systems it is much more dramatic if a mistake is made in this respect than in most other equipment. The equipment can always be dismantled and hand cleaned. One cannot do this with most membranes.

A chemical reaction can occur between the soil and cleaner coagulation and precipitation of protein, for instance; polymerization and plastification in the case of the reaction of aldehydes with peptines (polysaccharides used in jam manufacturing) by acids, etc. that can lead to serious trouble. Laboratory studies in the case of previously unknown soil types are recommended, the council of experienced personnel in membrane cleaning should be sought BEFORE fouling the membrane.

**MEMBRANE MATERIAL:**

A membrane surface is not as smooth as a microscopic scale as a polished metal surface. Under the powerful microscope it looks like a sponge, which it is in a way. The pores of the active filtrating layer are actually so small that even electron microscopes cannot “see” them, after all they are of the size of the molecules to be filtered. Most membrane material is hydrophobic, not liking water very well. When an aqueous solution with high surface tension comes into contact with a hydrophobic surface full of pores and holes, no wetting of the pore is achieved. The addition of surfactants will change this. The choice of surfactants depends on the chemical composition of the membrane. They must be compatible so that no damage to the membrane surface
occurs. This is where much research effort goes in developing cleaners for membrane systems.

The polarization potential of the membrane material previously mentioned also has an influence on the choice of cleaning procedures. It turns out that organic, polymeric membranes allow for highest water and product fluxes after cleaning when the last cleaning stop is alkaline. An acid rinse often leads to decreased water fluxes. On mineral, metallic membranes it is the opposite. This is due to desorption of Calcium ions which not only are removed in acid phase by dissolution, but also due to the positive charge on metal at acid pH, they are repulsed from the surface. Organic polymers become negatively charged at acid pH and will absorb a layer of Calcium ions. The use of an alkaline last step is therefore recommended in this case.

Metallic membranes can even be conditioned in their polarization for the specific type of product to be filtered, as the membrane will retain the polarization for quite a while. Charging it positively for the filtration of acid whey will lead to improved filtering capacity, for instance. On polymeric membranes this does not work, as the polarization does not hold long to be effective. Only chemical modification - attachment of specifically charged molecular groups - can achieve this.

DESIGN:

There are many different ways to design a membrane filtration module. From the standpoint of cleaning, some are easier to clean than others are, but all have their particular problems.

The design has a bearing on the flow pattern and on the type of structural support to hold the membrane. In the case of tubular membranes and hollow fiber modules, the fibers and/or tubes are arranged in a parallel way. This is more or less identical in design to a tubular heat exchanger. The problem is that if one or more of the tubes or fibers are clogged, or offer resistance to flow-through, it is not immediately realized. The fluid chooses the easiest way out and unless noticeable deviations in flux or flow or pressure occur, one might think the module to be clean.

Different module types have different types of support structure. In tubular modules, it is mostly the membrane in form of tubes with stainless steel casings. The cleaner must only consider the membrane itself. In plate/spacer modules and in spiral wound modules the cleaning solution can and will come into contact with the glues holding everything together, also with the spacer plates made of plastomers, with the retaining supports for spiral wounds. The compatibility of the cleaners with these materials must also be tested, and usually imposes yet another constraint on the composition of the cleaner.
Water:

Water is a good solvent, a good cleaner all by itself. For cleaning therefore we should strive to use good quality water in order to achieve the best results. Especially in membrane cleaning the quality of water is important. Whatever may be in the water could be filtered, concentrated and would deposit on the membrane surface, clogging it and thereby defeating the whole purpose of cleaning.

The pH of water should be 6-7.5, especially when cleaning Cellulose Acetate membranes, which are sensitive to higher pH values.

The water should not contain any “chlorine” as even low concentrations may, over the long periods of time of contact, endanger the membranes. This is particularly true of polyamide or thin film composite membranes, which are susceptible to oxidizers.

There should not be any considerable amounts of solids as they will be filtered out and soil the membranes. The same is true for the bacteriological status. It is not necessary to sterilize the water before, besides sterilization only kills, it does not remove the microorganisms themselves. Bad water can lead to bacteriological fouling if left standing for a while on membranes. There are bacteria, which might attack the membrane and digest it, in the case of natural derivatives (CA).

Metal ions, such as high amounts of iron or manganese are detrimental. Their effect is compounded when higher levels of silicate are present. The membranes might start to become brownish, blackish, and fluxes go down because of the silicate film that is deposited on the surface; whereas, iron and manganese might still be removable with certain chemical agents and/or acids (membrane specs permitting), silicates are almost impossible to remove. Hydrofluoric acid usually does it, but you might as well throw the membrane out. Operation succeeded, patient died!

High salt content of the chloride type is not recommended either. This is less for the benefit of the membranes, than for the supporting piping, tanks etc. The combination of chlorides with acids causes pitting corrosion and should be avoided!

Water hardness can be a big problem. Many plants use water softeners, ion exchangers, permeate water off their RO plant or boiler water for cleaning. The recommended water is the permeate water. Any water other than permeate may cause irreversible fouling. Check all water supplies.
CHEMISTRY:

For membrane cleaning there are basically three types:

- Alkaline cleaners with various types of buffer systems classifying them according to the pH range they generate;
- Neutral cleaners with or without enzymes;
- Acid cleaners.

Most cleaning can be done with a good alkaline product. Most types of soil that we encounter require - or are best removed with alkalinity. Protein, most any kind of protein, is more easily removed at high pH values. (figure 10.) At these pH values the protein also is slowly hydrolyzed, making it more soluble. As neutral values are approached, the solubility decreases, and at pH 4-5 many proteins can even be precipitated, they become quite insoluble and difficult to remove.

FAT:

Under normal conditions of cleaning (time, temperature and alkalinity usually encountered), not much hydrolysis (called saponification, the making of soap) occurs. The higher the alkalinity, the higher the temperature, the more fat will be hydrolyzed, leading to salts of fatty acids. If Calcium ions are around and not enough chelating power is in the cleaner (case of commodity caustic), then Calcium soaps, insoluble deposits will form which can clog up filters and also membranes. This should be avoided. Alkalinity based on caustic along, pH, is not sufficient. It is difficult to control the pH; no buffer system is there; no detergency. There simply is no soil carrying capacity present. Builders are needed! Sodium or potassium silicate, a favorite builder substance is not suitable on membranes. Silicates do not rinse very well, and precipitate easily, especially when pH drops into the acid range.

Sodium carbonate, Soda ash or phosphates are good builders and buffer system, however care must be taken to use well soluble material. Do not use the granular type, which might dissolve too slowly and get into the membrane system where it might physically damage the surface by scratching it.

The curve of protein solubility suggests that the higher the pH the better the cleaning. We also know that in most cases we simply cannot use pH values of 13 or more, seldom more than 12.5 due to the construction of the membrane. Built products have an enormous advantage over straight caustic. With the inclusion of various sequestrants, chelating or complexing agents into the formula increasing detergency, a built product can allow for the reduction of pH while making retention of cleaning efficiency possible. Sequestrants also, or primarily, react with the Calcium and magnesium ions present in either the soil or the hard water employed or both. They aid greatly in soil removal.
NEUTRAL CLEANERS:

Neutral cleaners are usually “enzyme cleaners.” Certain membranes, such as the CA and some sensitive composite membranes, do not support pH values higher than 7.5 or 9.5 respectively. As the protein solubility curve indicates, this is a bad region for efficient soil removal. In order to make a product, which is buffered to give a pH value of 7.5, or 8 in solution do a good cleaning job on protein, an enzyme (similar to protease of the stomach) is added.

The enzyme slowly digests the protein molecules and makes them into water-soluble fragments. To speed up the action of the enzyme, one should work at the optimum pH of the enzyme activity, which is about pH 9 (already too high to CA) and at temperature around 120°F which may also be too high for some membranes. One could increase the amount of enzyme in the cleaner, as more enzyme molecules will be able to do more work. This is however costly. Enzyme cleaners are not only just composed of an enzyme preparation, they have builders and buffers, surfactants for emulsifying and dispersing soil.

Depending on the type of soil, it is possible to make a neutral cleaner of quality without enzymes (a lot less expensive) if no protein is present in the soil or without surfactants when no fat is present. Enzymes other than proteases have not been tried on a large scale, mostly because of the cost factor involved.

ACIDS

An acid cleaning step can often be skipped when a powerful quality cleaner has been used. It is recommended to use acids when high amounts of mineral deposits, Calcium, Magnesium, Iron are present in the soil or in conditioning the membrane surface in the case of inorganic membranes. A blend of acids (nitric/phosphoric/citric) correctly chosen is usually better than straight commodities.

Among other things the blend is easier to handle, has the purity not always found in raw materials (an important factor in membrane cleaning) and the benefit of the various advantages of the pure acids?

SOLVENTS

Solvents such as chlorinated hydrocarbons or petroleum derivatives are not recommended in membrane cleaning. Compatibility with the membranes or the support material is often not assured, cleaning is restricted to only a particular type of soil (oil and grease, emulsions), and toxic and environmental hazards make these cleaners more and more obsolete.
OXIDIZERS:

Sodium (or potassium) hypochlorite, chlorine bleaches, is often used for cleaning and sanitizing. It helps in protein removal, but is corrosive, not only on stainless steel, but on certain membranes such as PA or TC. There are other disadvantages. Even on PS there are limitations as to concentration and temperature. Again, certain effects seem to work together, but in different ways than on stainless steel. Whereas on steel the recommendation with respect to chlorinated cleaners is to remain at high pH in order to decrease the chance of corrosion, the polymeric material suffers more from the combination of high alkalinity plus chlorine than from mild alkaline chlorine bleach alone. If membrane specs state temperature range from 60° F to 140° F, pH range 2 to 12 and chlorine level tolerated up to 300 PPM, that does NOT mean that it is safe to operate at 140°F, pH 12 and 300 PPM simultaneously.

The temperature tolerance is given at similar conditions. What one can do is a matter of negotiation between the user, the manufacturer and the supplier.

HYDROGEN PEROXIDE:

Hydrogen peroxide is used as a cleaning booster in some applications, not as effective as chlorine, but also not as destructive. In membrane systems it is sometimes used for cleaning and once again, but cautioned to review the membrane specifications before use.
3.6 **CIP Water Quality**

Water used for flushing, cleaning and disinfecting of membrane filtration plants must conform to the following standards to obtain best possible service.

It is a prerequisite that the following standards be adhered to for membrane guarantee to be valid. It is also recommended that the water be analyzed at least every three months to ensure proper quality. If the water quality does not meet these standards, consult a Niro representative. Every six months the analysis must be sent to Niro for review.

- Iron Less than 0.05 PPM
- Manganese (MN) Less than 0.02 PPM
- Silicate (SiO₂) Less than 10 PPM
- Aluminum (Al) Less than 1 PPM
- Hardness as (CaCO₂) Less than 10 gr/gal (170 PPM)
- Particles Less than 25 microns
- Turbidity Less than 1 NTU
- Silt Index Less than 2.5 SDI
- Total Plate Count Less than 1000 per ml
- Coli Count 0 per 100 ml
- Chlorine (RO and NF only) 0 PPM
3.7 **Oxidizer Intolerance**

If you have a reverse osmosis or nano-filtration system, the membranes have no tolerance for oxidizers. Introduction of any oxidizers, especially chlorine (sodium hypochlorite), will cause permanent damage.

Niro will not assume any responsibility for damaged membranes of oxidizers come in contact with the membrane.
3.8 **Defoamer Intolerance**

Use of anti-foaming agents is not recommended since they can cause irreversible loss of flux.* If use of anti-foaming is necessary, please consult a Niro representative.

No chemical that has not been approved by Niro should be used for membrane cleaning or shall come in contact with the membranes.

Niro will not assume any responsibility for damaged membranes if unapproved chemicals come in contact with the membranes.

* A common component of anti-foaming agents in silicon, which is the primary cause of the flux loss. Silicon is also found in many lubricants, which also should not come in contact with the membranes.
All plant personnel must be familiar with these instructions. NIRO will not assume any responsibility for personal injury or equipment damage caused by faulty operation.
4.1 **Safety Declaration**

All personnel managing or operating the plant, together with all personnel having access to the plant must be familiar with the contents of this Manual, and especially those instructions involving Health and Safety.

Special attention and appropriate action must be taken where any component or location is marked with a warning sign.

Warning signs shall be respected, never removed, defaced, or obstructed, and replaced when damaged or lost. New signs shall be installed when a new potential hazard is noticed.

Niro Inc. has no responsibility for personnel injury, fatality, or equipment damage resulting from plant operation that deviates from the products and quantities defined in Section 1 (System Description) of this Manual.

The plant shall only be used for the product(s) and quantities stated in this manual and only in accordance with the technical and safety data stated in the manual.

In the event the plant is to be used for a product or products not stated in this manual, Niro Inc. shall be notified using the attached documentation sheet.

Safety guidelines (given in Section 3 of this manual) supplement State and Federal safety rules established for the location specified in Section 1 of this manual.
CHANGE OF OWNERSHIP

We____________________________________________________ (Customer)
Have taken over ownership of plant type__________________________________
Supplied to__________________________________________________________ (original customer)
Under Niro Inc. order number__________________________________________
The plant was designed for____________________________________________
With a feed rate (lbs./hr.)______________________________________________
The new product is_____________________________________________________
And the new feed rate (lbs./hr.) is_______________________________________

We request that Niro Inc. inform us as to whether processing of the new product in the
above plant is possible as configured. If feasible, we request recommended operating
conditions, and whether new safety directives will be required. If not feasible, we request
that Niro Inc. provide us with a proposal for the necessary modification.

Signed:_____________________
Position:___________________
Date:_______________________
To:

Niro Inc.
1600 O’Keefe Road
Hudson, WI 54016

CHANGE OF PRODUCT

We______________________________________________________(Customer)
Operating plant type______________________________________________
Niro Inc. order number___________________________________________
The plant was designed for________________________________________
With a feed rate (lbs./hr.)_________________________________________
Wish to use this plant for__________________________________________(new product
With a new feed rate (lbs./hr.) of_____________________________________

We request that Niro Inc. inform us as to whether processing of the new product in the
above plant is possible as configured. If feasible, we request recommended operating
conditions, and whether new safety directives will be required. If not feasible, we request
that Niro Inc. provide us with a proposal for the necessary modification.

Signed:_____________________
Position:____________________
Date:_______________________
General Safety Procedures continued

4.2 **General Safety Procedures**

Process plants incorporate a combination of components, for example: rotating machinery, various electrical devices, ductwork for transporting gas under low and high temperature vacuum and pressure, as well as various liquid piping. Each of these areas must be treated with respect to avoid personal injury or death as well as damage to the equipment. Always read and follow warning signs and labels.

When entering equipment, always wear appropriate clothing, ear and eye protection, footwear, hard-hat, hair net, and fall protection equipment. Long hair should be tied back and placed under hair net and/or hard-hat. Loose clothing, which may become caught in equipment, is not permitted. Jewelry can also get caught or provide a conductive path and is not permitted.

Never operate equipment without guards in place.

Take particular care during rainy or icy conditions as you enter plant components that are located outdoors. The grating, checker plate, and platforms can be slippery.

Before entering a vessel, identify possible hazards and be certain it has been thoroughly vented to remove traces of unburned combustible gases, inert atmospheres or cleaning products, which could result in severe respiratory problems and subsequent injury or death. Do not enter until: 1) satisfied that normal atmospheric conditions exist in the vessel and are confirmed safe with appropriate testing equipment, 2) that any interconnection electrical equipment and process piping is isolated, and that 3) a WARNING sign is placed on vessel indicating work in-process.

It is important to make sure that your company has a LOCKOUT/TAGOUT and CONFINED SPACE procedure and that you completely understand each one respectively and follow them.

Respect plant interlocks. They are built into the system to prevent personal injury and protect equipment. Do not alter, jumper, or bypass any interlock without first consulting with Niro Inc. and obtaining written confirmation.

Never operate the system beyond the design capacities without first consulting with the Niro Inc., who supplied the equipment. This applies to all components including pumps, fans filters, valves, heaters, etc.

Never disable an alarm because it is a nuisance or for any other reason. Correct the problem instead.
General Safety Procedures continued

Never touch any component unless absolutely certain of its temperature. Even though insulated and cladding are present, some surfaces may still be hot enough to result in personal injury.

Before operating any component, such as a fan, valve, heater, pump etc., thoroughly review and understand the vendor’s instructions available in the plant manual.

Always operate and maintain equipment in accordance with the equipment manufacturer’s instruction, particularly with regard to lubrication and replacement parts.

Be aware of any abrupt change in vibration, smell, or noise level of any equipment. This maybe evidence of failed components and warn of a dangerous situation. When in doubt, shut down the system per the system requirements and thoroughly investigate.

Keep good records of normal operations and breakdowns. Review them to predict failures and avoid accidents.

Never permit dangerous makeshift repairs. Maintain adequate spare parts and inventories. Keep the proper tools on hand, so that they are available when required.

Never perform maintenance or repair work of any kind on plant components while plant is in operation.

All plant components must be vented thoroughly before any maintenance or repair work involving welding, grinding, cutting or drilling is carried out, so as to avoid risk of fire and explosions. The safe atmosphere must be tested and confirmed with appropriate testing equipment.

Maintain coordination between the operating, maintenance and safety/inspection departments.

Require regular refresher training in safety practices and procedures for all plant personnel and insure that all new personnel receive the same training.

As the plant is a process system, anyone in its vicinity must be fully alert and aware of the operation when on plant premises, and not be impaired by illness, drugs or alcohol.
General Safety Procedures continued

Finally, when in doubt, ASK! We will gladly assist your operating personnel in any area of equipment operation that was supplied by Niro Inc.
General Safety Procedures continued

4.3 Rotating Mechanical Equipment

To avoid serious personal injury, death, or property damage, it is extremely important that you follow the safety instructions listed below. If you do not understand any of these instructions, DO NOT PROCEED any further until you have obtained a clarification, which clearly answers your question.

All person’s that will install, operate or maintain the equipment should read and thoroughly understand the operating, installation and maintenance manual supplied with the system first.

Do not operate the equipment until all guards and covers are mounted in their proper location and all doors are closed. If the equipment is not supplied with a warning sign, a suitable sign must be placed on the equipment immediately (as shown below, or an equivalent).

!!! WARNING !!!

GUARDS, ACCESS DOORS AND COVERS
MUST BE SECURED IN PLACE
BEFORE OPERATING THIS EQUIPMENT

LOCK OUT POWER
BEFORE SERVICING OR REMOVING
GUARDS, ACCESS DOORS AND COVERS

Fail to follow these instructions
May result in personal injury or property damage.

Do not open any doors or remove any covers or guards while the equipment is in operation, unless these openings are properly protected by grates or screens to prevent entry and/or discharge of solid objects.

Do not inset hands, feet, tools, or other foreign objects into any equipment while it is in operation. Any of these actions could result in bodily harm or death.

Lockout Provisions

Before performing any work or inspection in proximity to moving parts, it is imperative that associated motor disconnects and/or circuit breakers be locked in the open (off) position. Individuals should personally place their own individually keyed padlock on the disconnect in a manner that will guarantee a de-energized condition. The key should be keep on the persons body and NEVER left near
the padlock. Under no circumstances should the lock be removed by anyone other than the person who placed it on the disconnect.

Similarly, be certain to shut off/de-energize (bleed off pressure) and lock out all pneumatic and hydraulically operated components, steam systems and electrical circuits supplying power to control functions if these systems are independent of the main supply. Any rotating elements should be firmly blocked to prevent accidental rotation. If the equipment is not supplied with a warning sign, a suitable sign must be placed on the equipment without delay (as shown below, or an equivalent)

!!! WARNING !!!

DO NOT OPEN UNTIL THE POWER HAS BEEN LOCKED OFF AND THE SHAFT HAS STOPPED ROTATING

FAILURE TO DO THIS CAN RESULT IN SERIOUS BODILY INJURY

If it is necessary or required to perform work inside or around a piece of equipment, e.g. for cleaning or maintenance, two or more persons should work as a team with at least one person outside the unit at all times. The outside person should NEVER leave while someone is inside the unit. You must follow your company’s CONFINED SPACE ENTRY and LOCKOUT procedure.

Certain procedures – maintenance, adjustment, etc. – may require access to the machine while in operation. This work should be done only by qualified and properly trained persons who have management approval.

All rotating equipment shall be regularly inspected and properly maintained in accordance with recommended maintenance instructions and procedures contained elsewhere in this manual.

No person should be allowed to ride on, step on, or cross over rotating equipment, nor to walk or climb on structures, without using the walkways, stairs, ladders, and crossovers provided.

Good housekeeping is a prerequisite for safe working conditions. All areas around rotating equipment, and particularly those surrounding drives, walkways, safety devices, and control stations, should be kept free of debris and obstacles, including inactive or unused equipment. The floor should be kept clean of product and/or chemical or solvent spills.
General Safety Procedures continued

DO NOT remove or paint over any safety or warning signs. These signs are provided for your safety. Obsolete or non-applicable warning signs or posted instructions should be removed at the direction of management in a timely fashion.
4.4 **Electrical Safety**

General

All power distribution equipment, control panels, and instruments contain hazardous voltage, which can kill or maim personnel. Proper operation and maintenance significantly reduce the degree of hazard. Only a qualified electrician should be permitted to service and maintain electrical components.

Routine observations should be used to look for signs of electrical problems. Unusually hot surfaces or burnt smells should be investigated promptly and the cause corrected by a qualified electrician.

Operation

Improper operation of electrical equipment can create an unsafe situation. The access to such equipment must be limited to personnel who are qualified and familiar with not only the equipment being operated but also associated pieces of equipment and all hazards involved with such equipment.

Hazardous Voltage

Electrical enclosures contain hazardous voltages and must remain closed when in operation. Many enclosures have multiple sources of voltage. A complete understanding of the connections of each piece of equipment is necessary. So all sources of power to the equipment can be lockout/tagout according to your companies procedures before access to the equipment is permitted. **DO NOT, ANY UNDER CIRCUMSTANCE, USE ELECTRICAL ENCLOSURES FOR STORAGE!**

Adjustments

It is possible to misadjust equipment, causing an unsafe or unsatisfactory situation. Before making any adjustment, the result of that change must be evaluated to ensure equipment operation and personnel safety is maintained. Instructions furnished for specific pieces of equipment should be consulted for functional adjustments.

Failures

Blown fuses, tripped breakers, or tripped overloads are indication that a potentially hazardous situation exists and the cause of the overload must be determined before equipment is returned to service. Failure to determine and correct the cause of the overload may result in equipment damage and a
General Safety Procedures continued

personnel risk.

If a fuse has blown or breaker tripped, excessive currents may have caused damage to electrical equipment. The equipment involved should be checked for damage and repaired, if necessary, before being returned to service.

Fuses, circuit breakers, overloads, and all other electrical devices must only be replaced with devices having identical voltage and current ratings and operating characteristics. Current capacities, trip characteristics, and interrupting capabilities must not be changed unless a detailed evaluation of the distribution circuit and loading is performed and a change is truly warranted.

Maintenance

There is a hazard of electrical shock whenever working on or near electrical equipment. TURN POWER OFF using your companies’ lockout/tagout procedure before working on electrical equipment. Only trained, qualified, personnel should work on electrical equipment and only when using appropriate procedures, tools, apparel, and equipment. Verify that all stored energy has been discharged before working on the unit.

The goal of maintenance is to keep all equipment and components in good working order. Failure to repair minor problems often lead to major failures later. A complete inspection of mechanical integrity should be performed at least once every year and after any major fault to check for loose or missing parts or other signs of necessary repairs.

Terminals, fuse clips, cable, and bus power and ground connections should be inspected for evidence of loosening or overheating. As necessary, contacts should be cleaned and loose terminals tightened or replaced.

Moving parts should be inspected to assure that they are freely moving without binding or sticking and are not badly worn. Any part showing doubtful performance should be repaired or replaced.

Ventilation passages must be kept open. If equipment depends on auxiliary cooling, periodic inspection should be performed with filter replacements as needed.

Electrical enclosures must not be used for storage of any material, equipment, or personal properly.

When equipment is repaired, use only factory approved parts and procedures.
General Safety Procedures continued

When making repairs, inspect parts being installed for any deterioration due to improper storage.
General Safety Procedures continued

4.5 *High Pressure Equipment*

Pressure vessels are liable to fail if the pressure exceeds the maximum allowable working pressure. Major contributors for failure include but are not limited to sudden changes in the operating conditions or blockage of the flow passages downstream. Such a failure may cause economic and personnel losses. Therefore, pressure-relieving devices are used to minimize the potential loss of human life and economic investments.

This device can be either a safety relief valve or rupture disk. The pressure at which the valve opens or disk ruptures is set a little higher than the normal operating pressure. Valves are costlier than the rupture disks. However, they relieve the excess pressure above the set pressure without seriously interrupting the process. Valves, being spring loaded, close by themselves after the excess pressure is released. On the other hand, when a disk ruptures the pressure inside is equalized with the outside and the process is interrupted until the disk can be replaced.

If your plant is processing corrosive fluids, the pressure-relieving device may be a combination of rupture disk and relief valve. This combination reduces losses in case of over-pressure to a level comparable to a safety valve system. The advantage is that the rupture disk is made of corrosion proof material while the valve is made of carbon steel. The later is less expensive to replace.

The need for safety relief valves or vent valves is established depending upon the design conditions and the types of fluids handled. Safety relief valves are normally installed on the vapor/gas side. Vent valves are necessary on both the shell and the tube side to vent the inert and other undesirable materials.

The discharge from all relief mechanisms must be handled safely and in a manner appropriate for the materials being released. If it is air, water, or any other harmless fluid it should be piped to the outside and released to the atmosphere. If it is a hazardous or polluting fluid, the valve/rupture disk outlet is piped to a proper storage tank so that the fluid is not released into the atmosphere.

Pressure relief devices should be checked periodically to ensure that they are in good working order.

Maintenance of high-pressure equipment is extremely important to safety. The following steps should be followed:

Vacuum breaking and pressure relieving devices must be checked regularly. A periodic in-service inspection is necessary for safety. Corrosion, erosion and
General Safety Procedures continued

other kinds of damage, leakage, and cracks etc. must be identified and corrected immediately in order to avoid accidents.

A pressure vessel should never be drilled, cut, or welded, by anyone not appropriately qualified. Any repair work should be stress-relieved depending on the material of construction, its thickness, and code requirements.

Periodic cleaning of heat transfer surfaces should be done to remove the fouling/scaling that results in reduced thermal performance and increased pressure drop. After cleaning, the equipment should be tested for leakage by hydraulic or pneumatic pressure tests. Every time the unit is reassembled, a new set of gaskets should be used to prevent leakage. Since old gaskets generally do not seat well a second time. Bolt tightening should be done according to a sequenced procedure so that the gasketed joint is not damaged.

Adequate record of maintenance should be kept for future reference.

Welds in critical areas (length, circumference and nozzle to vessel head joints) should be examined regularly. Cracks may occur when hydrogen is present (electrode or environment) and gets into them during the fit up while welding. A radiographic examination immediately after the welding may not show any defects since these defects take time to develop.

Care should be taken to minimize corrosion on the outside of the vessel.

The following precautions should be observed when unbolting flanged connections:

When piping is unbolted, the piping may spring out due to cold stress, misalignment, and/or weight-induced movements. Sudden movements can hurt the workers and nearby equipment.

Similarly, if manholes are unbolted too quickly, pressure and accumulated liquid can be released. Consequently, the bolts should be loosened, but not completely removed. This will allow time for any accumulated pressure or liquid to be released and to see if the piping springs back. Only then should the bolts be carefully removed while taking care to hold the parts and prevent them from falling.
ATTENTION
SAFETY WARNING
REVERSE OSMOSIS CLAMPS

Because the reverse osmosis system employs operating pressures that are higher than normally encountered in dairy processing equipment, it is VERY IMPORTANT that only the proper types of clamps are used. When servicing the system, be sure that the proper type of clamp is used in the proper location. DO NOT substitute any other type of clamp than the ones shown below.

The high pressure bolted clamp is suitable for any Tri-clamp application. It must be used in any lines and connections in the high pressure piping circuits of the reverse osmosis system. For these lines in the high pressure circuit, do not use any other type of clamp! These clamps are properly tightened when the two halves of the clamp are butted together.

The low pressure hinged clamp is suitable for low pressure applications in any size. Do not use these types of clamps in high pressure circuits.
General Safety Procedures continued

4.7 **High Temperature Equipment**

High surface temperatures are typical for almost all processing equipment. These high temperatures pose a safety risk to personnel working within the building and close to high temperature surfaces. Personnel protection can be provided by guarding or insulation. Satisfactory insulation materials include mineral wool blankets or rigid fiber glass board able to withstand the anticipated temperature of the hot face (High temperature surfaces).

**Personnel Protection**

Proper training and supervision are necessary to avoid injury or death of personnel working in any capacity around equipment, which is operating at high pressure, temperature, or vacuum. Your Safety Engineer/Director should evaluate each new installation for potential hazards and provide appropriate training.

Adequate warning signs and identification labels must be posted and maintained to make personnel aware of the presence of the high temperature, pressure, or vacuum.

Attire appropriate to the particular environment including, but not limited to good quality helmets, gloves, goggles, and safety shoes must be required.
4.8 Pump Safety Notice

It is unsafe to operate a centrifugal pump when both the suction and discharge ports are closed off by valves at the same time. Such circumstances can result in the disintegration of the pump housing.

This phenomenon is fully appreciated in the engineering profession and stated in the pump literature. When a pump operates with closed valves, nearly all the motor power output is converted to heat and the temperature of the trapped liquid will continue to rise.

As it does, the liquid will expand and additional pressure will be created as the liquid expands eventually to above the liquid boiling point. The temperature will eventually stabilize where heat losses from the pump housing equal the heat generated. However at this point the internal pressure may exceed that for which the pump was designed.
General Safety Procedures continued

4.9  **Guidelines for Good Manufacturing Practices (GMP)**  
**For Design and Operation of Niro Plant**

These guidelines are *advisory* hygienic principles for the manufacturer of dairy and food products. They do not replace or supersede any requirements from the regulatory agencies. Nor do they replace any more stringent GMP already in place at the plant site.

These guidelines are to be included in the Operational and Maintenance (O&M) Manual of plants designed and supplied for dairy and food products. Each client should evaluate the content of the guidelines and adopt where appropriate.
General Safety Procedures continued

Guidelines for Good Manufacturing Practices (GMP)

For

Design and Operation of Niro Plant

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7. Product Storage and Transportation
8. Plant Hygiene and Process Control Administration
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1.0  Considerations for Personnel at a Food Plant

General

The maintenance of hygiene standards is a fundamental responsibility of all personnel on a site.

Standards should be defined by the manager responsible for plant hygiene in consultation with other site managers and in accordance with the requirements of official agencies having jurisdiction.

Standards should be encompassed in a code of practice particular to the site.

Contamination of clean areas by inappropriate behavior of personnel must be prevented and where complete conformity is impossible, special care should be taken to prevent contamination of dry areas.

Movement of personnel throughout the site must be controlled. Areas should be designated according to the activity carried out within them; i.e. raw material, processing, finished goods, and access to these areas must be restricted to those personnel who work within a respective area.

Labels on clothing can be used to indicate authority to enter a particular area. However, the use of color-coded clothing and footwear will give greater control of the movement of personnel.

The necessary movement from one area to another must be accompanied by a change of protective clothing, including footwear.

A major factor in cross-contamination is footwear. The use of disinfectant footbaths/hygiene pads at the entrance to each designated area can reduce risk, but these also can be a source of contamination if not managed properly, as they are a source of moisture within the building.

Limiting the points of access to each area will reduce the risk of contamination, and personnel should be restricted to using only designated entrances/exits according to the needs of their job.

Hygiene Training

Managers of plant should arrange for adequate and continuing training of all personnel, in hygienic handling of food and in personal hygiene, so that they understand the precautions necessary to prevent the contamination of dairy and
General Safety Procedures continued

food products.

Medical

Persons who may/will come into contact with dairy and food products or dairy and food processing equipment in the course of their work should receive a medical examination prior to employment.

Medical examination of a food handler should be carried out at other times when clinically or epidemiological indicated.

Persons known or suspected to be suffering from a disease likely to be transmitted by food should not be permitted to work in food handling areas, in any capacity where there is any potential for food contamination.

Persons afflicted with wounds, skin infections, sores, or diarrhea must not be permitted to work in any capacity in which there is any likelihood of such a person directly or indirectly contaminating dairy and food products.

It is essential that all wounds, sores, cuts, grazes, boils, infected areas, running noses are reported immediately. Wounds should be covered with a suitable waterproof dressing and, where appropriate, this should be covered with a glove.

Cleaning of Hands

Production personnel should clean their hands frequently and particularly at the following times:

Before entering a production area.
After visiting the toilet.
After each break/meal.
After using a handkerchief.
After handling waste.
After completing any task where hands become soiled.
After smoking.

Personnel who are not production personnel: engineers and office staff should adhere to the production hand cleaning regime when having a reason to enter a production area.

Personal Hygiene and Dress

All personnel entering production areas should wear clean protective clothing,
General Safety Procedures continued

including head covering and footwear.

Prospective clothing should be washable unless designated for one time use only.

Protective clothing should be stored on the premises and not used for purposes off the premises, such as visiting other sites and traveling to and from work.

Where there is a risk of contaminating product, hair not completely covered by a hat should be enclosed by a fine mesh hair net.

Where there is a risk of contaminating product, beards and moustaches also should be completely covered by suitable designed headwear.

Protective clothing should be frequently laundered.

Jewelry and watches should not be worn in production areas, except for plain rings.

Coins and small personal effects should not be taken into the production area.

Gloves used in the handling of raw materials, dairy and food products should be maintained in good and sanitary condition. The wearing of gloves should not exempt a person from adhering to hand cleaning requirements.

Personal Behavior

The use of tobacco should be strictly forbidden in all production areas. If permitted on the premises, it should be restricted to special areas designated for this purpose.

Personnel using designated smoking areas should remove protective clothing before entering such areas and must wash their hands thoroughly before donning protective clothing and re-entering production areas.

The carrying of smoking equipment into production areas should be prohibited.

The eating of food and chewing of gum or tobacco should be prohibited in production areas.

The unhygienic practice of spitting should be prohibited.

Food and local agricultural product like eggs, meat, and vegetables should not be
General Safety Procedures continued

brought onto the premises for the purposes of sale or barter.

Animals should not be brought onto the premises, and encouragement of bird or animal feeding should be forbidden.

Visitors and Contractors

Visitors to the premises should be minimized. They should be prevented from handling and contaminating food and should only enter dry areas by special permission of the site manager.

Protective clothing conforming to the same standards as clothing supplied to production personnel should be kept for use by visitors.

Contractors working on the site should be provided with protective clothing, which complies with the same standard as that provided to production personnel.

Contractors should comply with the same hygiene regulations as permanent staff.

2.0 Hygienic Operating Requirements

Process Buildings

Clean Areas should be identified and designated.

Rooms should be kept clean, in good repair and as far as practical, free from waste materials, surplus water, and water vapor.

In wet areas, the inside of the building should be cleaned with potable water at specified intervals. Pressure washing is not recommended for general use due to the potential for splashing and atomization of water particles. A logbook should be maintained that shows dates that walls, ceiling, and plant structures were cleaned.

In dry areas, the building should preferably be cleaned by a vacuum system. If a central vacuum system is used, then the discharge air must be directed to the outside of building where it is not possible for the inlet air to pickup the exhaust air. It is recommended that all vacuum units be regularly tested for microorganisms. A logbook should be maintained that shows dates that walls, ceiling, and plant structures were cleaned with pre-certified vacuum equipment.
The use of compressed air is not recommended for cleaning. Brushes may be used if vacuum equipment is not available.

All non-food waste must be removed in suitably marked and covered receptacles. These must be removed on a routine basis, at least daily. All reusable receptacles should be cleaned before being brought into the building.

All discarded product must be removed in covered containers that are color coded to identify them from acceptable product. Under NO circumstance shall downgraded product be placed in the same packaging or containers as acceptable product.

The hopper for waste dusts or debris from the central vacuum system should be located outside the building and well away from air inlets.

**Process Air**

All product-containing surfaces should be cleaned immediately after use.

All wet equipment should be cleaned, according to the section on cleaning after each production run with intermediate cleaners as specified.

Dry cleaning of other areas should take place according to the schedule appropriate for the particular plant and process. A log should be kept of all dry cleaning.

**Utensils**

Equipment and utensils should be disinfected immediately before use and whenever there has been the possibility of contamination.

After cleaning, liquid product, contact equipment and utensils should be stored in a bath of sterile solution until used.

If disposable utensils are unavailable, all dry cleaning equipment used inside the process plant, such as brushes, should be washed, soaked in a sterile solution, dried and stored in plastic bags until ready for use. This equipment should be color coded to distinguish it from general floor sweeping equipment., etc.

**Fabrics**

Where fabrics are used, they should be washed, disinfected, and dried after each period of use, except where used in collection systems of powder products. When used in collection systems they should be removed and exchanged at
General Safety Procedures continued

specified and recorded intervals.

Maintenance

Equipment repairs and maintenance should preferably be carried out after production runs are finished. Screens should be provided, where practical, to avoid product contamination.

Any personnel entering equipment should be provided with disposable and washable overalls, which include head protection, overboots, and gloves. Access should be restricted to nominated persons.

Tools and replacement parts that enter product spaces should be properly cleaned before being brought into the building.

Any access doors being opened on an infrequent basis should be carefully cleaned before opening to avoid any contamination, Particularly around the seal area. Opening of access doors to the process should be kept to an absolute minimum.

Aromatic Substances

Cleaning preparations, paint, and other aromatic substances may only be used when there is no product present.
General Safety Procedures continued

**Air Movement**
The operating environment should be maintained such that the movement of air, to the extent possible, is from the clean to the dirty parts of the process. The use of loading bays; personnel doors; and the operation, cleaning and shutdown of plant must all cater to this requirement.

**Ceilings and Walls**
The ceilings and walls of the building structure must be regularly inspected and cleaned as necessary to prevent accumulation of debris.

**Structural Steel**
Exposed structural steel must be regularly inspected and cleaned as necessary to prevent accumulation of debris.

**Lifting Equipment**
Overhead stationary or traveling lifting equipment such as cable hoists used for servicing process equipment must be cleaned and inspected regularly to prevent accumulation of debris.

### 3.0 Cleaning and Disinfecting of Plant and Equipment

**Frequency of Cleaning and Disinfecting**
Equipment used for handling food in which water is a continuous phase should be cleaned and disinfected after each period of use and at least once per day.

As it is impracticable to dismantle and clean manually all contact surfaces, cleaning-in-place is carried out by circulating suitable solutions. Nevertheless, equipment should be inspected periodically and manually cleaned using suitable brushes when appropriate. Where possible, equipment such as pumps, valves, plate heat exchanges, and pipelines should be dismantled for inspection and for manual cleaning at frequent intervals.

Where, after pasteurization, intermediate products are held at temperatures and time that will support bacterial growth (50° F to 146° F), samples should be tested to determine cleaning frequency. In the case of balance tanks used to store concentrated product between evaporation and finishing, cleaning should take place at intervals of not more than 4 hours.
Equipment in contact with dry products should be dry cleaned when necessary. Wet cleaning should be carried out when there has been an accumulation of solid materials, or if the equipment is implicated in a bacteriological deterioration of the product, or where there has been a lengthy shutdown.

Where twin filters are used, these should be alternated every three hours or when a pressure differential builds up, and the one which is taken off line is cleaned and disinfected.

Air filters should be inspected and cleaned regularly, according to a predetermined schedule based on the manufacturer’s recommendation and/or measurement of the pressure drop across the filter.

C.I.P. spray nozzles should be examined periodically according to the hygienic schedule, to ensure the effective distribution of detergent and disinfectant.

Plant and equipment should always be wet-cleaned before re-use, following periods of shutdown and especially following maintenance.

Plant and equipment should always be cleaned before start-up after prolonged periods of inactivity.

Either immediately after cessation of work for the day or at such other times as may be appropriate, floors, including gulleys, auxiliary structures, walls of food handling areas and windows should be thoroughly cleaned.

Production scheduling should be organized such that all cleaning sequences can be carried out immediately after the appropriate section of plant becomes available.

All equipment such as sampling utensils, manual aids to agitation, etc. should be cleaned after use, stored appropriately and disinfected before use. The bacteriological conditions of such equipment should be checked regularly.

**Wet Cleaning**

The basic steps of plant and equipment cleaning comprise:

Rinsing with water to remove gross dirt. Water temperature of 104° F to 140° F is recommended. However, a temperature of 180° F may be needed.

Cleaning treatments with detergent/acid/caustic solution at appropriate velocity
General Safety Procedures continued

and temperature so that all dirt is removed from the surface.

One or more rinses with clean potable water of adequate duration on the cleaned surfaces to remove contaminants and detergent solution.

Application of disinfectant and appropriate sanitizer is applied at the required concentration and temperature.

Complete removal of water from areas where the potential for aerial contamination may give rise to subsequent microbiological growth.

It is important that when hot solutions are used for cleaning (or disinfecting), that there should be adequate and suitable air venting of vessels (such as bulk liquid silos) which might be subject to collapse if the internal pressure were reduced on subsequent cooling.

Where a spray drying chamber and ancillary equipment are wet cleaned, it is essential that:

Complete removal of all products is effected.

Water must not be allowed to find its way forward to the dry area.

No wet areas must be retained within the drying chambers and ancillary equipment.

All areas should be dried before re-use by passing hot air through the plant.

Product contact areas of equipment that are wet cleaned should be physically isolated from those parts of the plant, which operate under dry continuous conditions. If any structural deterioration is noted, this should be reported to management immediately.

Dry Cleaning

Persons entering the equipment for the purposes of cleaning (or maintenance) should use special clean protective clothing and shoe covers.

Product recovered from the system, during dry cleaning or on re-start after dry cleaning must be kept separate from normal production in clearly identifiable containers.

Powder deposits should be removed from the system by means of a vacuum
General Safety Procedures continued

cleaner. If brushes are used, precautions should be taken to ensure that they are well disinfected.

Compressed air is not recommended for dislodging powder because of the potential for spreading contaminated material.

The potentials for contaminating sieves during dry cleaning is great, and it is preferable to exchange sieves that are clean, disinfected and dry for soiled sieves. If sieves are cleaned without exchange, operators must wear gloves and use disinfected brushes and utensils.

Recessed areas associated with inspection hatches, access doors, and explosion vents must receive particular attention during a dry cleaning.

**Inspection**

The internal surface of the equipment must be checked regularly (at least annually) for cracks which might allow ingress of liquid containing solids into cladding walls. Particular attention should be paid to areas of stress such as welds, support structures, hammers, vibrators, etc.

Special attention should be paid to the state of repair of cladding, which, if allowed to become wet due to leaks, water spillage external presence of stress cracks, or other causes, may become a breeding ground for bacteria. If the cladding is found to be wet or implicated in any contamination, it should be removed and examined bacteriological with particular reference to Salmonella. Permanent removal should be considered as one of the options for future operation.

### 4.0 Waste and Hazardous Materials

**Storage and Disposal of Waste**

Waste materials should be stored in suitable receptacles and containers, which prevent contamination of product, plant, and equipment until disposal can be effected, and which prevents the attraction of pests.

Waste materials should be removed from processing areas as often as is necessary and at least daily.

The storage and disposal of waste should represent no hazard to potable water
supplies.

Access to waste materials should be prevented.

Receptacles and equipment used for the storage and disposal of waste should be cleaned and disinfected immediately after waste has been disposed of.

Plant or equipment accidentally being exposed to waste should be cleaned and disinfected immediately.

Areas used for the storage of waste should be managed effectively, cleaned, and disinfected routinely.

**Storage of Hazardous Substances**

Any substance, which may represent a hazard to health, must be clearly labeled with the name and use of substance and shall contain a warning about its toxicity.

Hazardous substances should be stored in locked rooms or cabinets designated only for that purpose.

Hazardous substances should be dispensed and handled only by authorized and properly trained personnel, or by persons under the supervision of trained personnel.

An inventory of hazardous substance should be kept and maintained along with emergency procedures and remedial action in case of exposure to personnel or accidental spillage.

The establishment’s nominated medical practitioner(s) should be kept aware of the identity of hazardous substances stored on the site.

Extreme care should be taken to avoid the contamination of food, clothing, and equipment when handling hazardous substances.

### 5.0 Pest Control

To minimize the risk of insect, rodent, and bird infestation, the following points should be noted. It is recommended that a professional pest control service be under contract to assure acceptable standards.
Avoid creating conditions that are attractive to insects, pests, birds, and rodents. This involves storing packing material and raw materials off the floor on clean pallets and away from walls. To facilitate inspections, it is recommended that there is room between the stacks.

Control measures, whether they involve treatment with chemical, physical, or biological agents, must be undertaken by suitably qualified personnel. Physical barriers are preferable to the use of chemicals.

Ensure that waste products, including packing material, are not allowed to lie on the floor or the ground, but collected at once and removed to the refuse area daily.

The Manager or his representative should accompany the Pest Control Contractor, when carrying out his duties. He should ensure that any recommendations made by the Contractor are carried out. The result of inspections and any remedial work should be recorded.

Appoint a member of the factory staff to inspect at least once a week to ensure that rodent baits are in a satisfactory condition, and that there are no signs of any pests. As soon as evidence of insects, birds, rodents, or other pests is noted or suspected, arrange an emergency visit by the Contractor.

Inspection of goods delivered to the plant is necessary to insure that no pests are present.

Ensure the inspection of returnable packaging materials and pallets for signs of pests and ensure the eradication of any infestation before re-use and dispatch.

Ensure that any manufactured product leaving the premises is free of infestation and is not in a condition likely to attract pests.

Make sure that all suppliers of packaging material, including pallets, operate to similar standards.

Since birds have been identified as a previous source of Salmonella contamination, measures should be taken to discourage them from becoming established in and around the plant.
General Safety Procedures continued

6.0 Processing and Packaging

Technically competent personnel should supervise all processing and packaging operations.

Areas designated for processing, packaging, and storage should be used only for the purpose intended and for no other use.

All processing and packaging operations should be so designated and managed so as to prevent the possibility of cross-contamination of finished products with intermediate products or raw materials.

Persons handling raw materials should not be capable of contaminating intermediate post-pasteurization products or finished products.

The exclusion of personnel from some parts of the establishment may be necessary to achieve this.

All processing and packaging steps should be performed without unnecessary delay and under conditions which will prevent the contamination, deterioration, or the development of pathogenic and spoilage micro-organisms in raw materials and intermediate products awaiting processing.

Dryer shut down procedures must be such as to ensure the complete evacuation of moisture laden air from the drying chamber, cyclones, transport ducts, fluid beds, bag filters, etc. Moisture laden air residing in the system will give rise to condensation on cooling, with the possibility of subsequent microbiological problems.

Product manufactured at the time of a breakdown or unplanned shutdown of the process should not be released for human consumption.

Material recovered from equipment and not the product of normal continuous processes should not be incorporated in the product, unless the hygienic quality can be ensured throughout recovery.

All packaging materials should be stored under clean, dry and hygienic conditions and should not be liable to contamination or infestation.

Packing materials should conform to the requirements of product to be packed.

Packaging materials should be non-toxic and not impart undesirable odors, flavors, compounds, or deposits to the product or otherwise contaminate it.
7.0 Product Storage and Transport

Product should be stored in clean hygienic conditions and not be subject to contamination, infestation, and damage by heat, moisture, or physical damage.

Storage areas should be periodically cleaned.

Product should be transported under clean hygienic conditions and not be subject to contamination, infestation, and damage by heat, moisture, or physical damage.

Damage to powder bags during storage can be repaired provided the bag liner has not been ruptured. If the bag liner has been ruptured, the powder must be removed for use as animal feed or disposal. Powder spillage should be immediately removed by vacuum cleaner.

Powder bags damaged during transport should be immediately segregated. If the bag liner has not been ruptured, the package can be repaired, otherwise the powder should be condemned for animal feed or disposal.

The wrapping of palletized powder with a polyethylene film, or similar substance, can help protect packaging during transport and assist load integrity.

One-trip layer pads between powder bags and pallet can prevent contamination/damage by the pallet, since a supply of perfectly satisfactory pallets can not always be guaranteed.

The packaging material must provide appropriate physical protection and protection against contamination to the product.

Packaging equipment used for standard products should not be used for the packaging of animal feed or waste product.

Animal feed and waste material should be packaged in containers, which are easily distinguishable from those used for human consumption.

Packages should be closed immediately after filling or gassing, and dust on the surface of the packaging should be removed.
General Safety Procedures continued

8.0 Plant Hygiene and Process Control Administration

A single member of plant staff, whose duties are independent of production, should be made responsible for hygiene and process control records.

Duties could include:

Definition of written cleaning procedures for entire plant with special reference to areas of plant that may be cleaned automatically.

Definition of permanent cleaning and disinfecting schedules to ensure that all parts of the establishment are cleaned appropriately and that critical areas, equipment, and material are designated for specific cleaning and/or disinfecting at defined intervals.

Training of staff in the use of special cleaning tools and the methods of dismantling equipment for cleaning, and their instruction in the identification of the routes of contamination and the hazards involved.

Maintenance of cleaning records, water treatment records, detergent solution strength control records, heat treatment records, and any other records relevant to plant hygiene and process control.

Monitoring of process control and laboratory records and ensuring remedial action is taken when there are persistent adverse trends in microbiological results.

Maintenance of process control and laboratory records.

Instituting a management audit system for the above.

9.0 Environmental Screening and Trend Monitoring

An environmental screening and trend monitoring program, consisting of routine microbiological sampling of plant and environment, enables the distribution and type of contamination to be clearly identified. Importantly, the data collected as result of such a program enables the assessment of risk, the prediction of problems, and the institution of corrective action.

Such a program should be developed as part of a factory’s code of hygienic
General Safety Procedures continued

practice, and from this, a protocol for managing microbiological contamination should be developed.

The program will require an established test frequency, based on an assessment of the likely risks.

However, particular points in the process will present greater risk than others and these should be determined by a Hazard Analysis and Critical Control Point (HACCP) survey.

Sampling will require the collection of solid and liquid material.

All sampling should be carried out with sterile equipment and as much material as possible should be recovered to enhance the sensitivity of the test.

Sample points can be divided into two categories: 1) Product Contact Surface and 2) Plant Environment.

Category 1 sampling points obviously concern any part of the process where product is in direct contact with plant or equipment. Sampling at such points allows an immediate assessment of the contamination associated with the product.

Category 2 sampling points include the following:

floors
walls
ceilings
plant and equipment surfaces
compressed air systems
vacuum systems
cleaning implements
drains

Sampling such points enables the microbiological condition of the environment to be monitored and the trend of contamination to be determined.

An increase in the level of certain bacteria, e.g. Coliforms, E. coli, above the normal background level, can, for example, indicate a breakdown in hygiene control. Such a breakdown could lead to the presence of pathogenic bacteria with the subsequent contamination of product contact surfaces and the product itself.
General Safety Procedures continued

By understanding microbiological trends in the plant environment, timely corrective action can be taken to reduce the risk to product.

Routine sampling of product contact surfaces and the plant environment also will monitor the effectiveness of cleaning programs and enable appropriate improvements.

10. Laboratory Control and Sampling Procedures

The establishment should be equipped with or have access to laboratory facilities which are sufficiently resourced to carry out all routine testing required to maintain continuous control of all operations and processes.

Quality standards must be elaborated for each product involving:

Sampling point
Quality criteria
Frequency of sampling
Critical control points
Analytical methods

The following should be monitored by the establishment laboratory through its own test procedures, or when necessary, through the services of an approved and authorized external laboratory:

Incoming products used in manufacture.
Other ingredients and raw materials.
Pasteurization and heat treatment processes.
Other processing and manufacturing processes.
Water quality
Calibration of instruments, e.g. Gauges, thermometers, etc. (The calibration itself may be carried out by the engineering department.)
Packaging materials.
Air quality.
Steam quality.
Microbiological monitoring of the environment within and immediately outside the plant.

Laboratory analytical procedures must follow recognized or standard methods.

Analytical results should be consistently monitored and significant deviation from
the norm should warrant an investigation as to the cause with appropriate corrective action instituted.

Testing for enter pathogenic organisms, such as Salmonella, must not be carried out within the confines of the establishment. Such testing should be carried out according to national legal standards.

A means of correlating analytical results with processing records should exist, as should a means of correlating analytical results with production batches.

11.0 Compositional Specification

Standard analytical methods should be used to confirm that the composition of end products conforms to the requirements of the specification.

Good manufacturing practice (GMP's) should ensure that when products are tested they are:

Free from microorganisms in any amount, which may represent a hazard to health.

Free from substances originating from microorganisms, particularly aflotoxins, in amounts which exceed the tolerances or criteria established by the official agency having jurisdiction.

Bibliography

“Guidelines for Good Hygienic Practice in the Manufacture of Milk – Based Powder”. The Association of British Preserved Milk Products. First edition, April, 1987

All plant personnel must be familiar with these instructions. NIRO will not assume any responsibility for personal injury or equipment damage caused by faulty operation.
5.1 **Maintenance Declaration**

The plant has been designed to good engineering practice where all reasonable steps have been taken to ensure safe trouble-free operation. However, to achieve continuing trouble-free operation, plant maintenance is required on a regular schedule basis, with maintenance carried out by personnel skilled in the maintenance of industrial plants, and who are familiar with the contents of this Instruction Manual.

Maintenance Instruction for the components making up the plant are stated in Section 6.

Maintenance must always be carried out under safe conditions of working as covered by governing local or national legislation. Experience over many years shows that this type of plant does not constitute any health and safety risk when carefully operated and maintained in accordance with the operating and maintenance instruction and normal industrial practice.
5.2 **Temperature and pH limits for membranes**

In order to achieve the specified performance and life of the installed elements, the membranes must be cleaned and operated at the proper temperature and pH's. Deviation from these requirements will result in shorter membrane service life.

**Micro-Filtration Membranes**

<table>
<thead>
<tr>
<th>Membrane Type</th>
<th>Process pH</th>
<th>CIP pH</th>
<th>Temperature Deg C</th>
</tr>
</thead>
<tbody>
<tr>
<td>PES</td>
<td>4 – 11</td>
<td>2 – 11.5</td>
<td>50</td>
</tr>
<tr>
<td>Ceramic</td>
<td>1 – 14</td>
<td>1 – 14</td>
<td>90</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>1 – 14</td>
<td>1 – 14</td>
<td>90</td>
</tr>
</tbody>
</table>

**UF Membranes**

<table>
<thead>
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<th>CIP pH</th>
<th>Temperature Deg C</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVDF</td>
<td>2 – 9</td>
<td>2 – 11</td>
<td>55</td>
</tr>
<tr>
<td>PES</td>
<td>2 – 10</td>
<td>2 – 11</td>
<td>55</td>
</tr>
</tbody>
</table>

**NF Membranes**

<table>
<thead>
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<th>Process pH</th>
<th>CIP pH</th>
<th>Temperature Deg C</th>
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</thead>
<tbody>
<tr>
<td>TFM</td>
<td>4 – 11</td>
<td>2 – 11.5</td>
<td>50</td>
</tr>
</tbody>
</table>

**RO Membranes**

<table>
<thead>
<tr>
<th>Membrane Type</th>
<th>Process pH</th>
<th>CIP pH</th>
<th>Temperature Deg C</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFC</td>
<td>4 – 10.5</td>
<td>1.7 – 11</td>
<td>50</td>
</tr>
</tbody>
</table>

The customer is fully responsible for the effect of un-approved chemicals on the installed elements. Their use will void the element warranty. The limits stated above are for guidance only and limits for your specific membrane listed in section 6.1 should be followed.
5.3 Membrane Warranty Claim Procedure

If the need should arise to send a membrane back to Niro for warranty purposes, please consult with a Niro representative before proceeding.

If after discussing the situation with a Niro representative it has been decided to send a membrane or membranes back to Niro Hudson, Inc., the following claim form must be filled out in full and faxed to Niro, attention Steve Prochnow (extension 186). Mr. Prochnow is also the individual from which to obtain a RGA number (return authorization number) for the claim form.

The membrane must be cleaned before shipping.

Thank you for your cooperation.
NIRO FILTRATION
MEMBRANE WARRANTY CLAIM

RGA # _______________   MR # _______________

(To be obtained from Niro before shipping)  (Niro use only)

Please fill the following form as complete as possible to expedite the claim.

Customer Name: ___________________________________________
Address: ___________________________________________
Contact Name: ___________________________________________
Phone Number: ___________________________________________
Telefax Number: ___________________________________________
Membrane Type: ___________________________________________
Quantity: ___________________________________________
Serial Number: ___________________________________________
Date Installed: ___________________________________________
Date Received at Plant: _____________________________________
Days In Service: ___________________________________________
Reason for Return: ___________________________________________

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

Description of system including product processed and location of the failed element:
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

Date: _______   Signature ________________________________________
SECTION 6 – COMPONENTS

COMPONENTS

All plant personnel must be familiar with these instructions. NIRO will not assume any responsibility for personal injury or equipment damage caused by faulty operation.
6.1 **Pumps**

Baldor Motor Maintenance Manual

Baldor Smartmotor Manual

Wanner Pump Manual

Wanner Pump Spare Parts

WARNING
OPERATES UNDER PRESSURE
SECURELY TIGHTEN ALL CONNECTIONS TO PREVENT LEAKS
6.2  Temperature Components

Tel-Tru Temperature Gauge
6.3 *Valves, Actuators and Positioners*

Tuchenhagen Butterfly Valve Cutsheet

Tuchenhagen Butterfly Valve Instructions
6.4 *Flow Components*

WARNING
OPERATES UNDER PRESSURE
SECURELY TIGHTEN ALL CONNECTIONS TO PREVENT LEAKS
6.5 Level Components
6.6 *Pressure Components*

Wika Pressure Gauge

WARNING
COMPONENTS MAY BE UNDER PRESSURE
FOR SAFE OPERATION, REFER ALSO TO SECTION 4:
“HIGH PRESSURE EQUIPMENT”
6.7 *Pre-filters*

WARNING
COMPONENTS MAY BE UNDER PRESSURE
RELIEVE PRESSURE BEFORE SERVICING
FOR SAFE OPERATION, REFER ALSO TO SECTION 4:
“HIGH PRESSURE EQUIPMENT”
6.8 *Membrane Element Housings*

Tami Ceramic Module Technical Instructions

DSS Lab 20 – Old Manual

DSS Labstack M20
6.9 *Miscellaneous*

Enerpac Hydraulic Unit
6.10 Controls
### 6.11 Useful Web Page Links

<table>
<thead>
<tr>
<th>Web Page</th>
<th>Link</th>
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<tbody>
<tr>
<td>UW Center for Dairy Research</td>
<td><a href="http://www.cdr.wisc.edu/">http://www.cdr.wisc.edu/</a></td>
</tr>
</tbody>
</table>
All plant personnel must be familiar with these instructions. NIRO will not assume any responsibility for personal injury or equipment damage caused by faulty operation.
7.1 **Spare Parts List**

B287 Recommended Spare Parts