Process Training
Cross Flow UF

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0. Contents

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1. DESIGN CONSIDERATIONS

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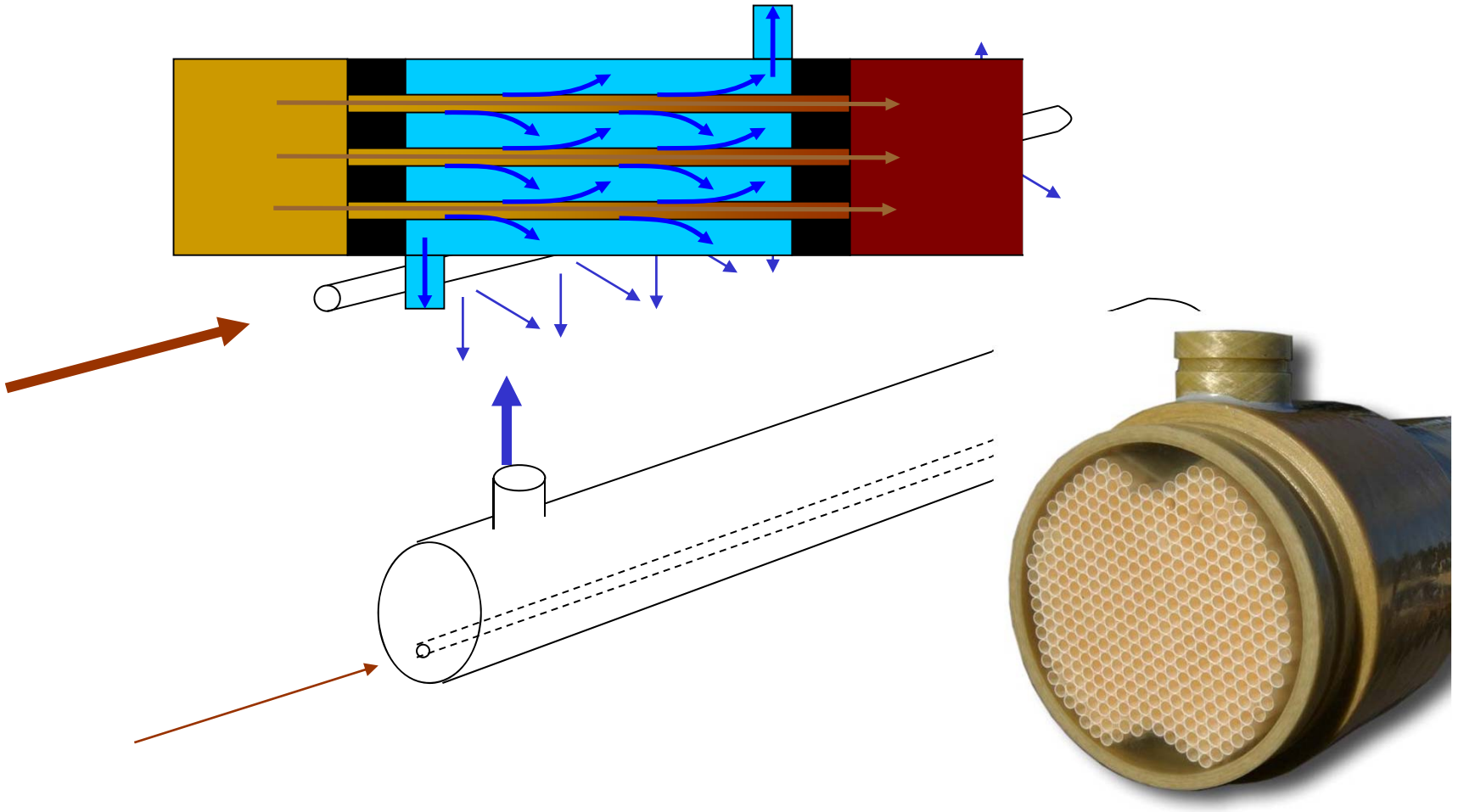
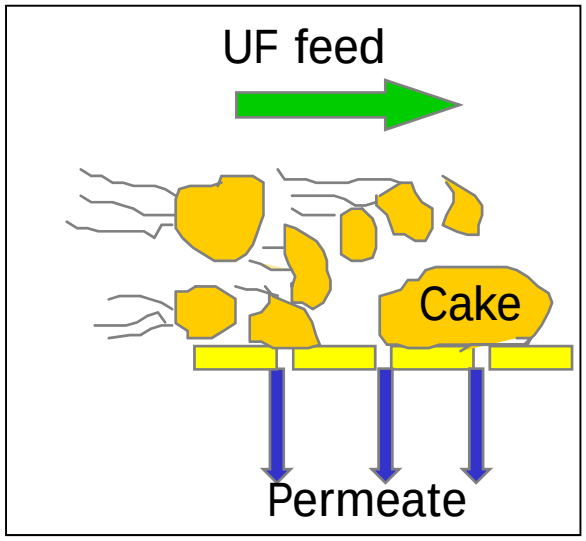
1-1 CF UF basics



1-2 Cross Flow Technology

Cross Flow Filtration



- Turbulent flow → minimal material build up
- Continuous concentrate discharge → long filtration runs

REQUIRED VELOCITY = 4 m/s

For 8mm CF UF membranes (FR 5385 type)

For 38GRH modules this equals 272 m^3/h

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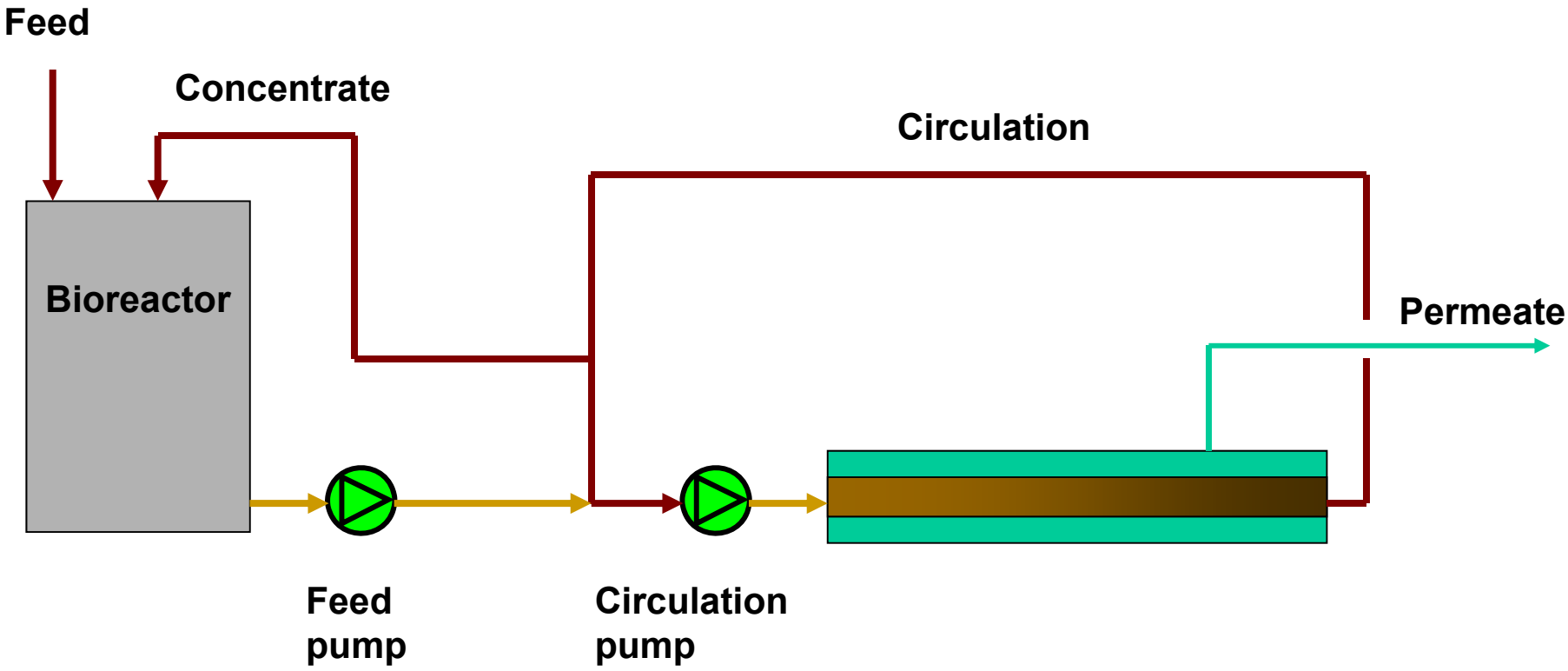
1-3 Cross Flow Technology Applied (1/4)



Feed to Bioreactor ≈ Permeate

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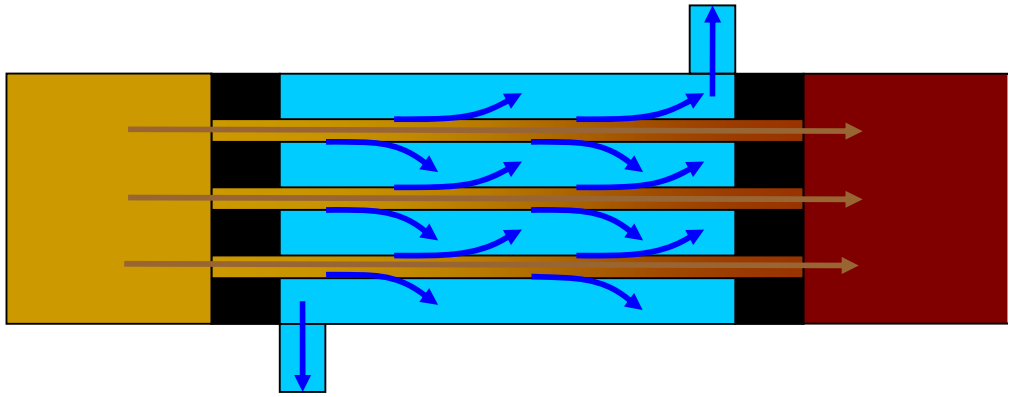
1-4 Concentration Factor

In 15 g/l



Out = 18,8 g/l

$$\frac{Concentration_{OUT}}{Concentration_{IN}} = concentrationfactor = 1.25$$

$$\frac{Feed\ Flow\left[m^3/h\right]}{Concentrate\ Flow\left[m^3/h\right]} = concentration\ factor = 1.25$$

FLOW RATIO FEED : CONCENTRATE : PERMEATE = 5 : 4 : 1

FEED FLOW = 5 x PERMEATE FLOW

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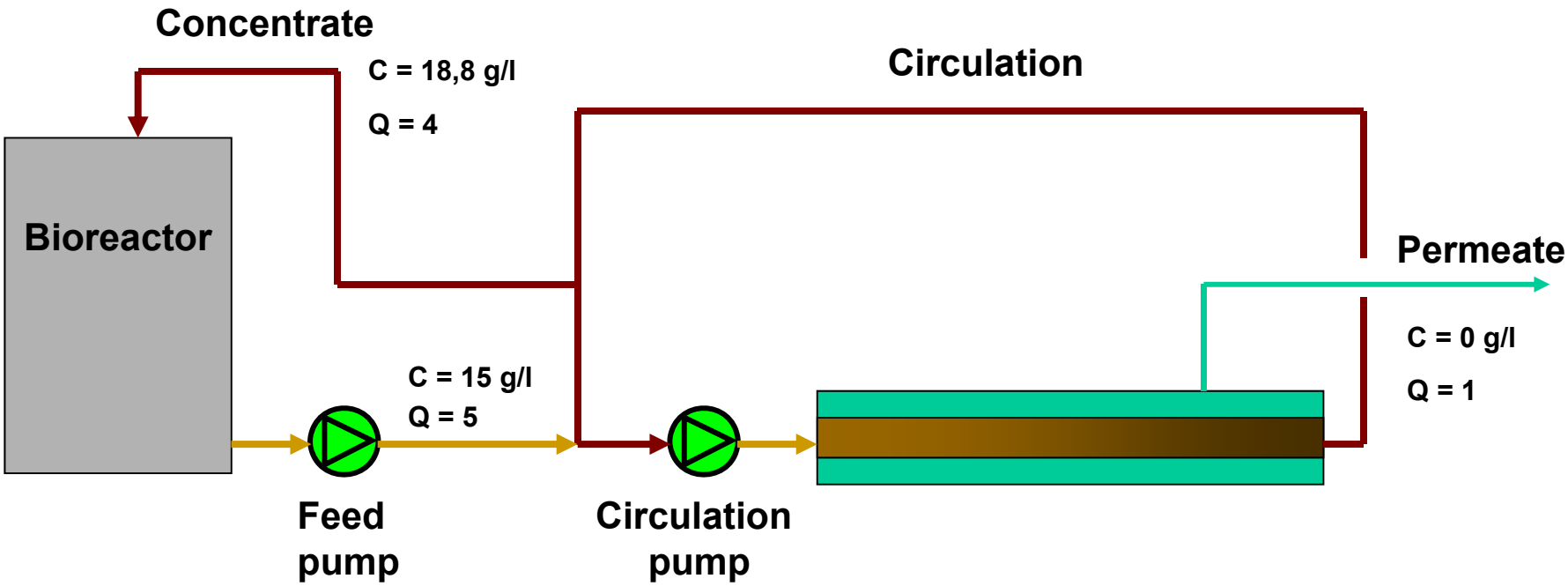
1-5 Cross Flow Technology Applied (2/4)



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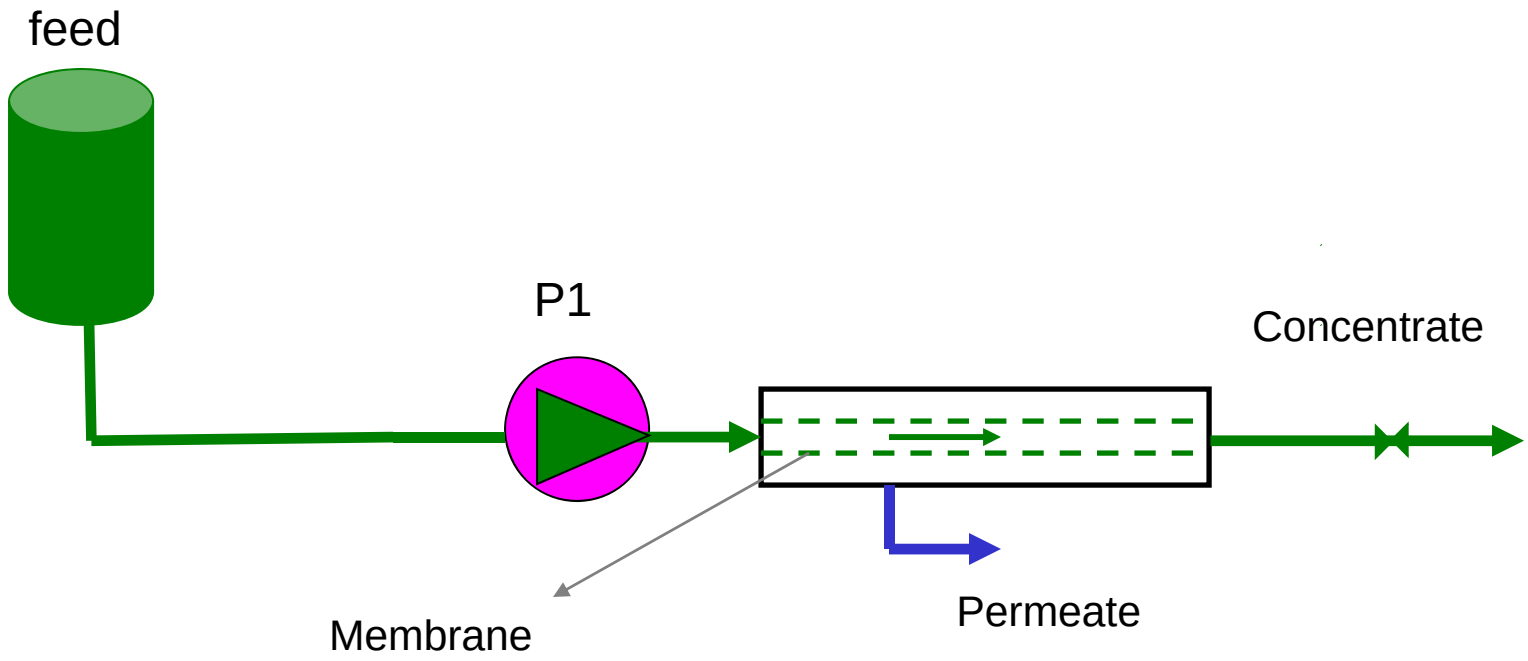
Principal Cross Flow Filtration (single pump); 1st Pilot plants



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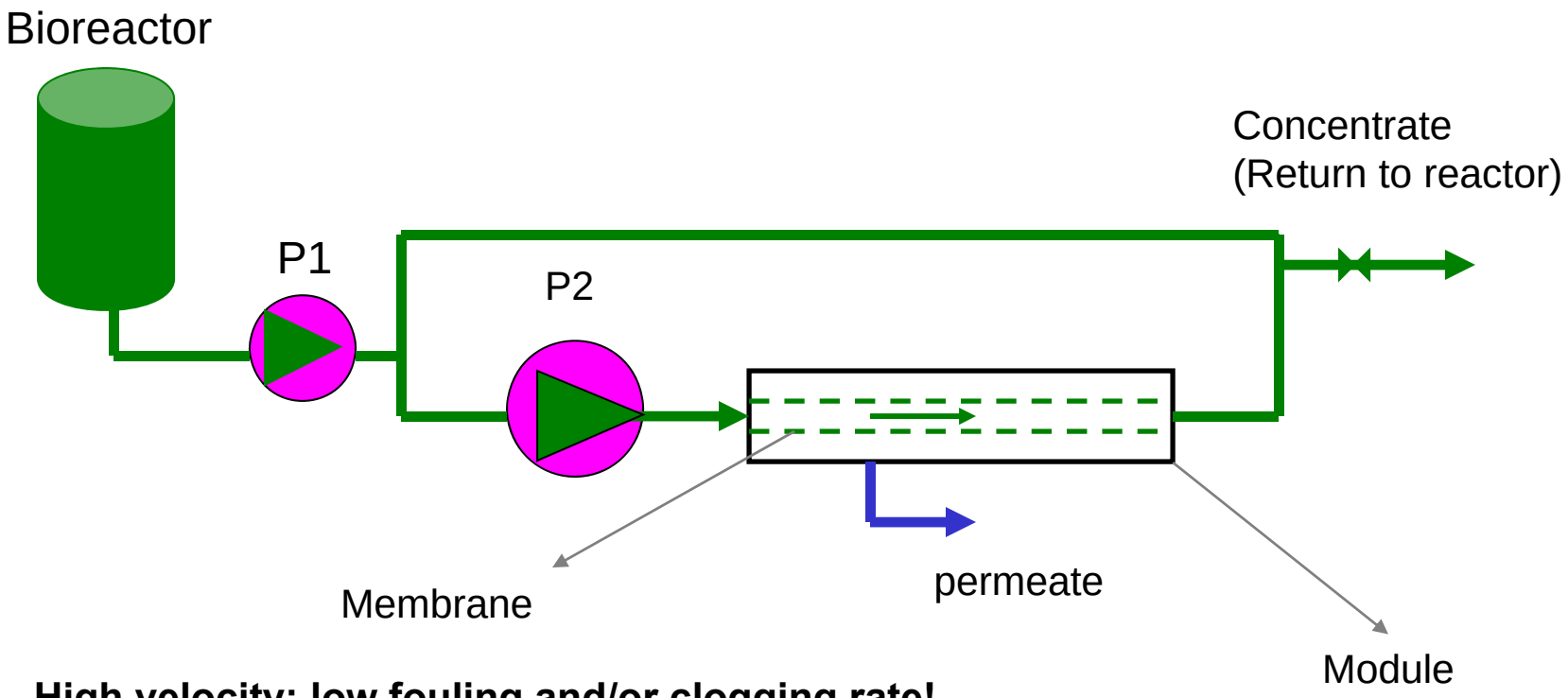
Principal Cross Flow Filtration (double pump)



High velocity; low fouling and/or clogging rate!

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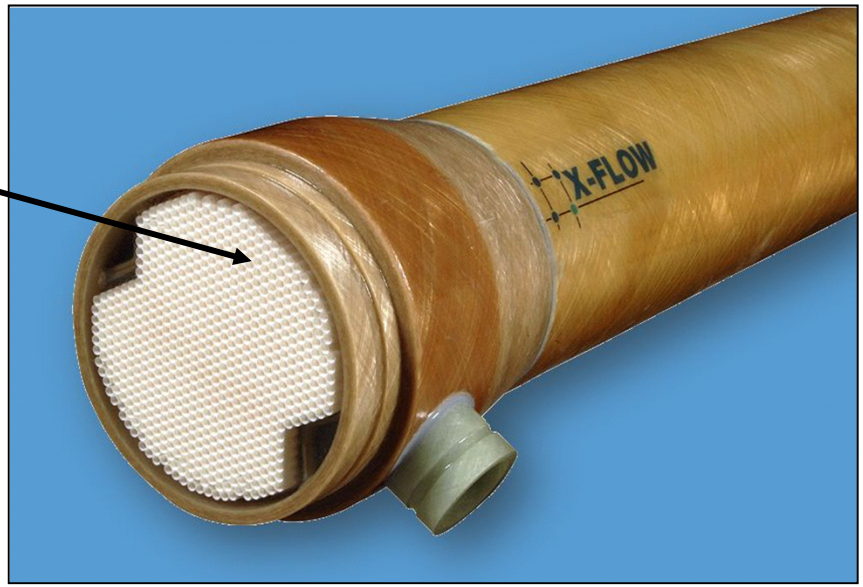
8 inch X-Flow
UF membrane
module (27 m2)

8 mm tubes
Length 3,0 m
Pore size 30 nm



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TECHNICAL SPECIFICATIONS

CrossFlow MBR

• membrane type:	F5385	(PVDF, 8,0 mm)
• module type:	38GR	(27 m^2/module)
• pore size:	30 nm	(0,03 µm)
• configuration:	(1x2, - 2x8) x n	(capacity)
• process:	cross flow	(2 - 4 m/s)
• flux:	40 - 130 lmh	(application dependent)
• TMP:	2 - 5 bar	(membrane limitation)
– **Burst pressure**	**> 20 bar**	
• membrane life time:	3 - 8 yr (technical)	(application dependent)
• cleaning:	CIP	(wastewater dependent)
– frequency:	1/month - 1/yr	
– duration:	2 hrs to ½ day	
– chemicals:	1-2% citric acid	
	500 ppm NaOCl	
	more specific cleaners in emergency cases	

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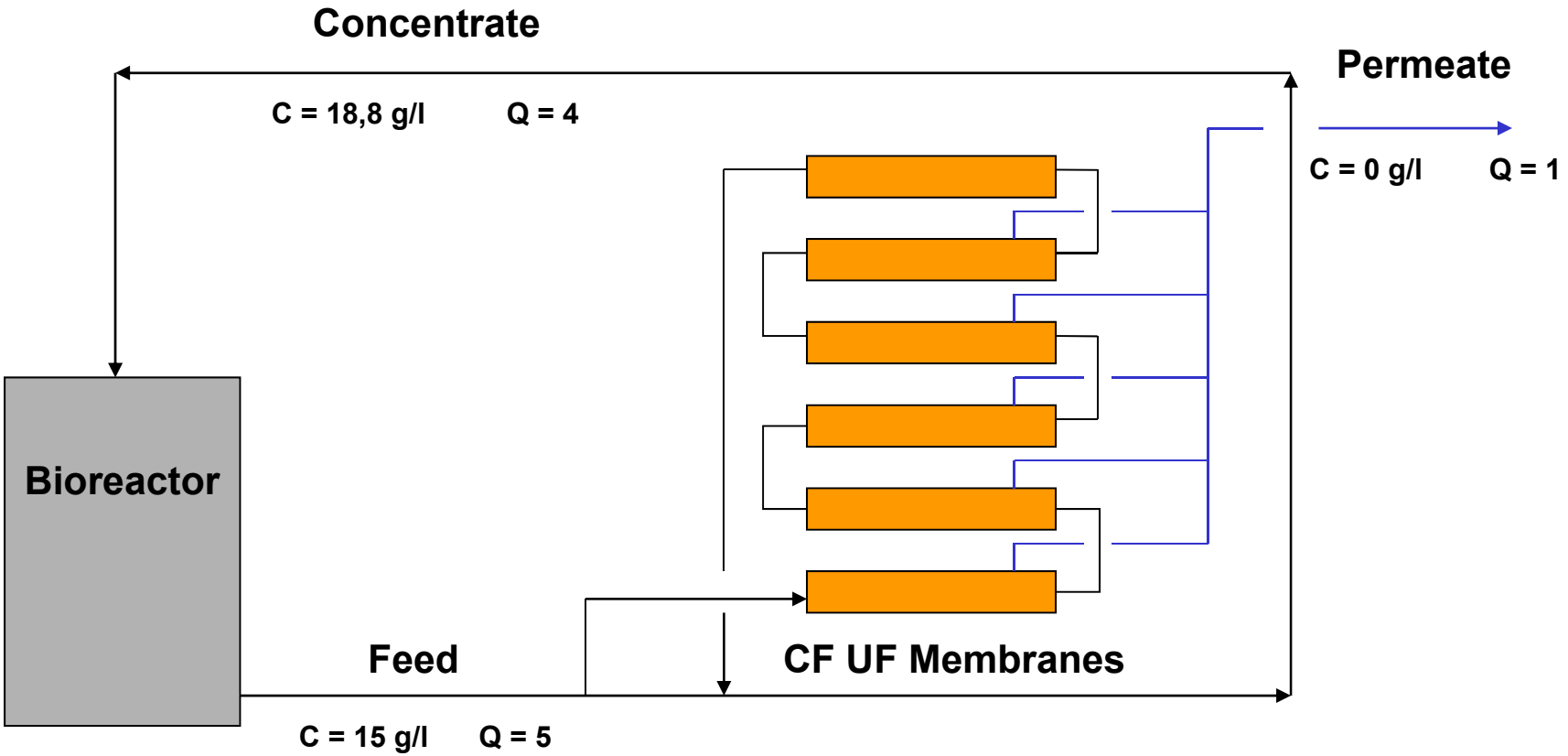
1-6 Cross Flow Technology Applied (3/4)



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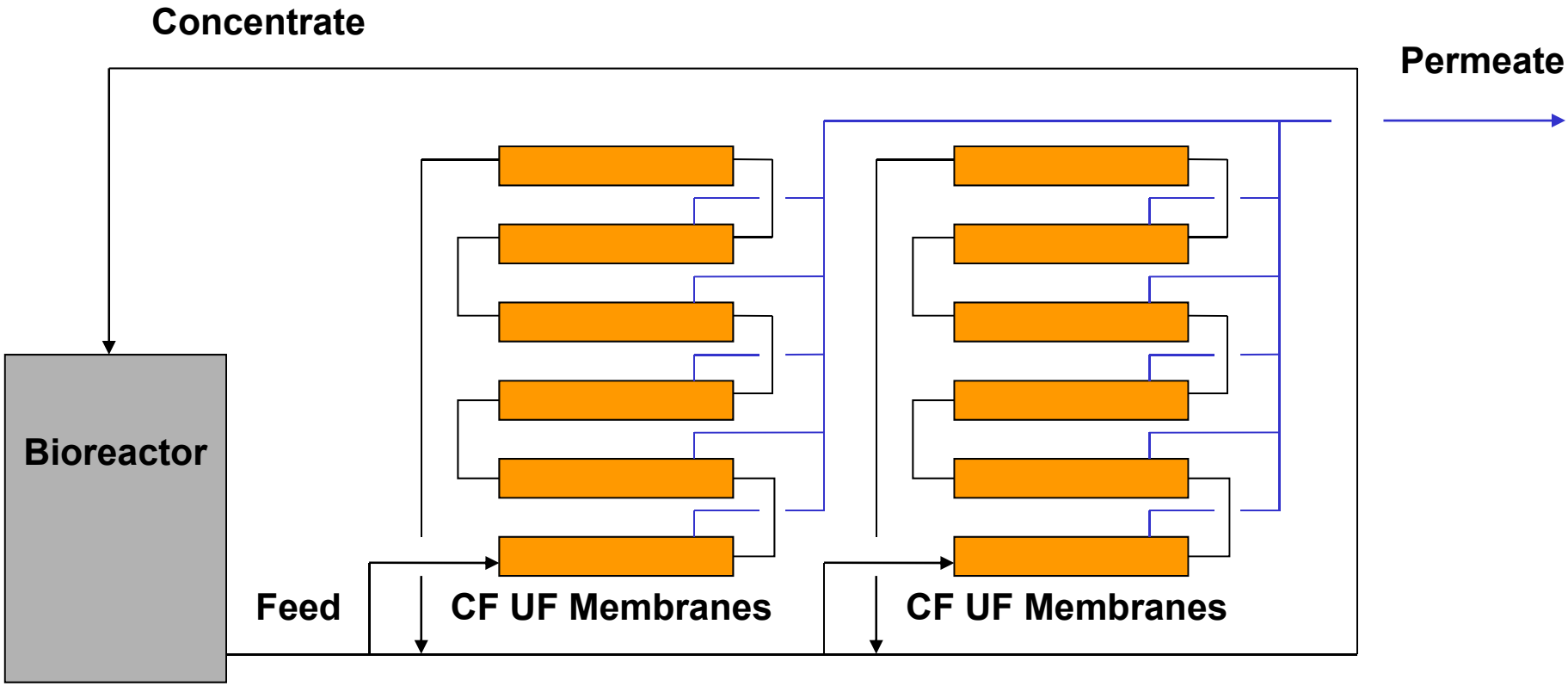
1-7 Cross Flow Technology Applied (4/4)



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1-8 Required Number of CF UF Membranes

Membrane surface of 1 module (GRH38 with FR 5385 membrane): 27 m^2

Flux is depending on application. Range: 40 – 130 l/m^2h^{-1}

Required amount of modules :

$$\frac{Permeate\ \ flow\left[m^3/h\right]\times 1000}{surface\left[m^2\right]\times\ flux\left[l/m^2\cdot h^{-1}\right]}$$

Install some spare!!!

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1-9 Example of Multiple Skids on 1 Feed section

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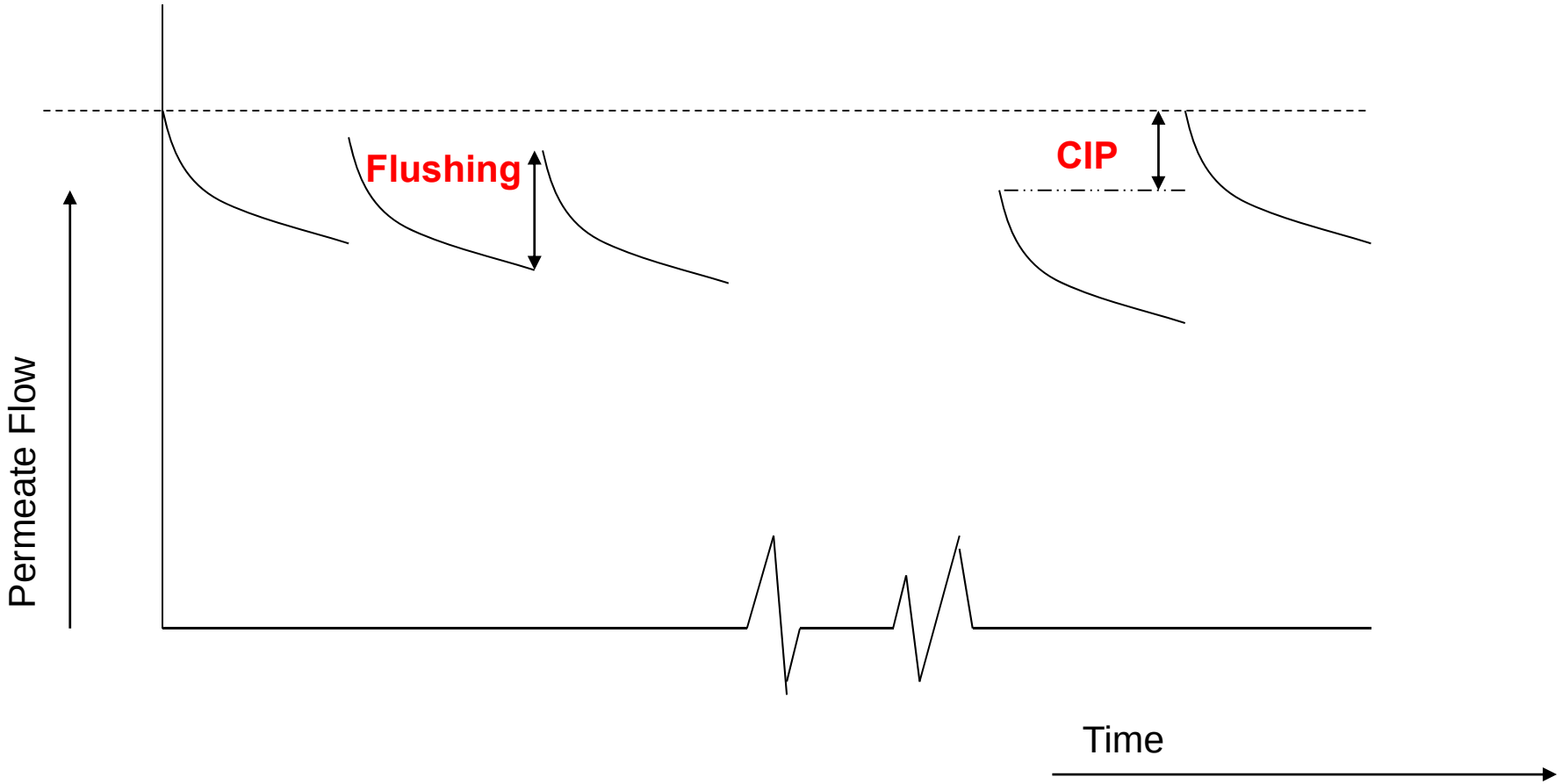
1-10 CF UF Cleaning



1-11 Design Specifications Flushing / CIP

Skid with **2 or 4** modules:

Permeate tank volume: 2,5 m^3 for each skid

CIP tank volume: 2,5 m^3

Skid with **6 or 8** modules:

Permeate tank volume: 4 m^3 for each skid

CIP tank volume: 4 m^3

CIP pump: 150 m^3/h

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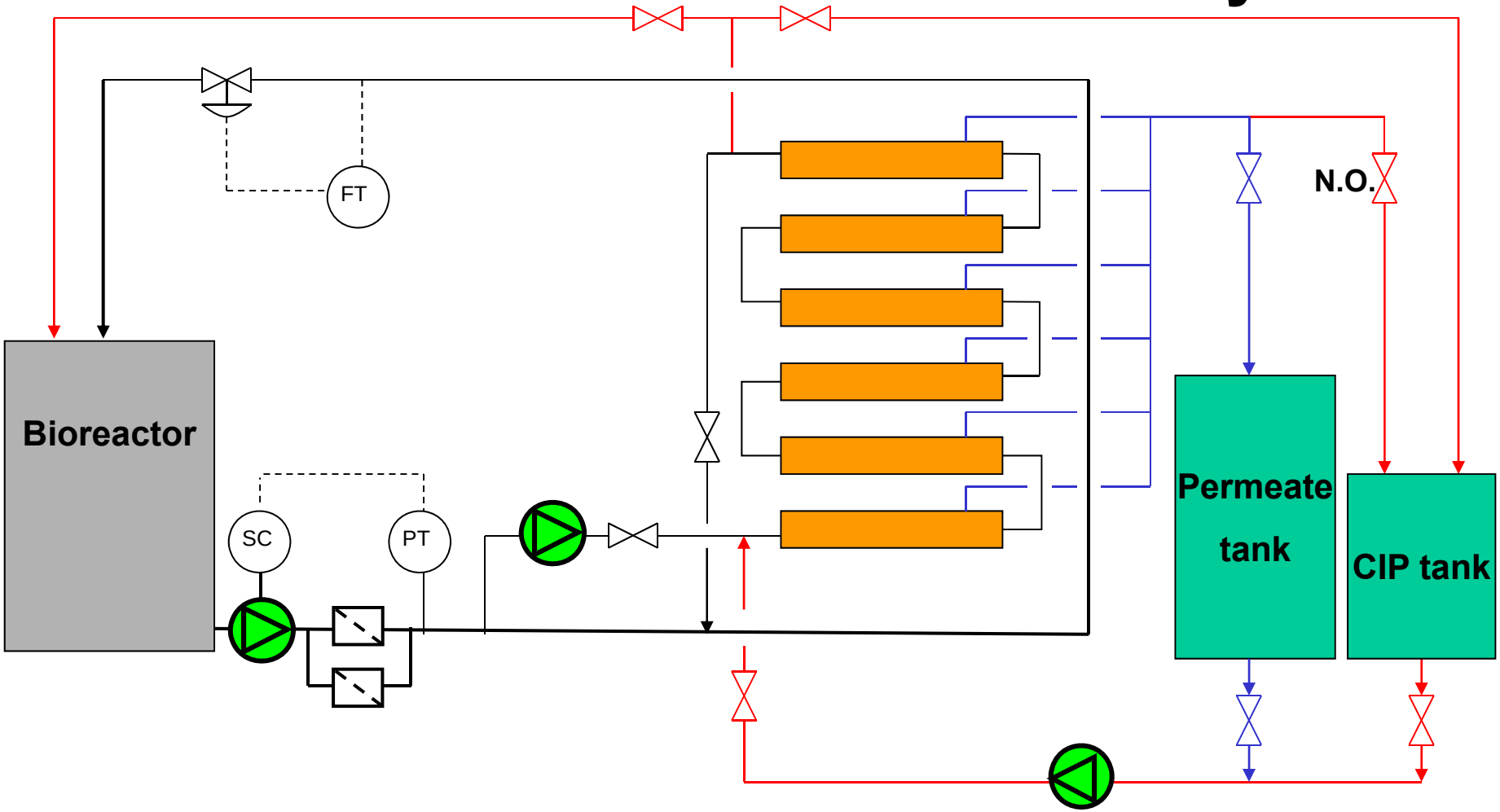
1-12 General overview of a CF UF system



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1-13 Summary of Design Considerations

<u>Cross Flow Pump:</u>	
Required Cross Flow Velocity:	4 m/s (=272 m^3/h)
Pressure drop for each module (@ 4 m/s):	0,9 bar (=0,8 + 0,1 bar)
<u>Feed Pump</u>	
Concentration factor:	1,25
Flow ratio FEED:CONCENTRATE:PERMEATE:	5 : 4 : 1
<u>Other:</u>	
Volume of permeate tank:	2,5 or 4 m^3 for each UF skid
Volume of CIP tank:	2,5 or 4 m^3
Flow rate CIP pump:	150 m^3/h

1-14 Points of attention

A. Pre-screening

B. TMP distribution

C. Prevent negative TMP

1-15 Pre-screening

If the performance of the pre-screening is not good:

- Materials will block the entry of the module
- The pressure drop of the UF unit increases
- The velocity inside the membranes decreases
- No turbulent circumstances
- Material build up inside membrane
- Membranes are clogged and need to be cleaned manually by Norit's service engineer.

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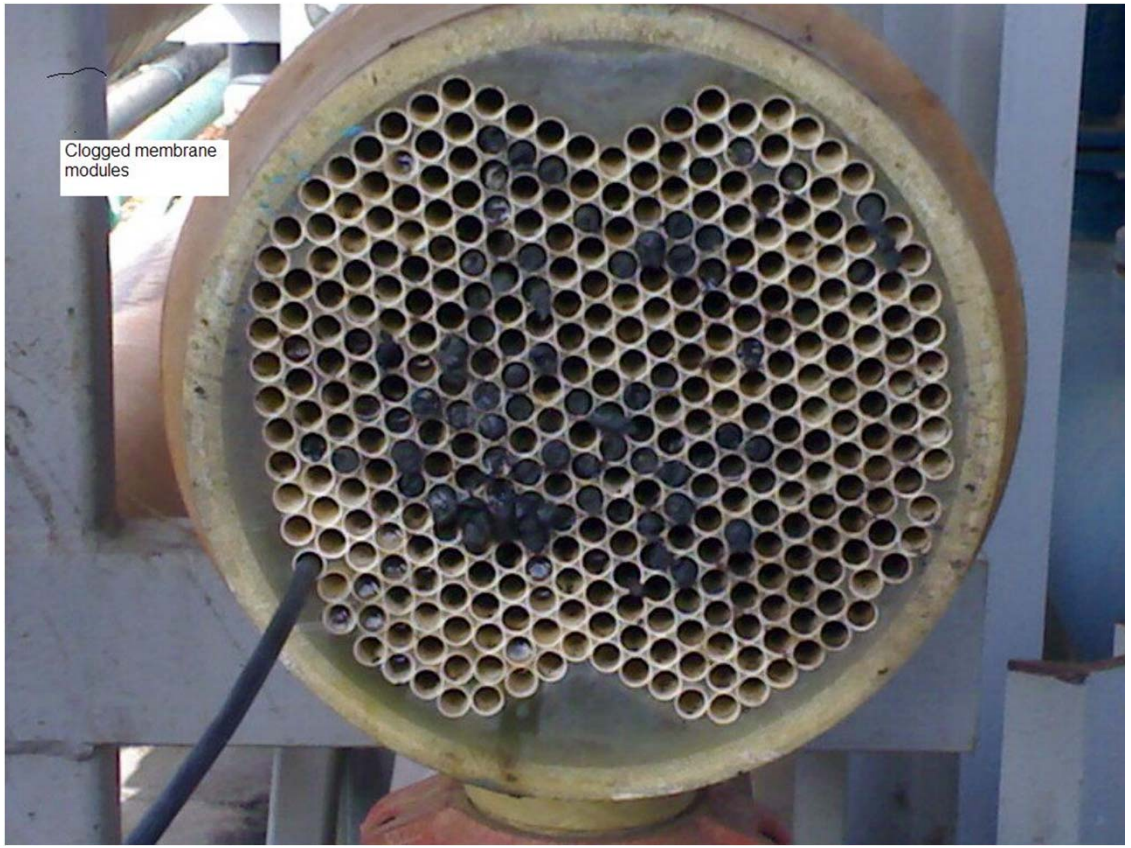
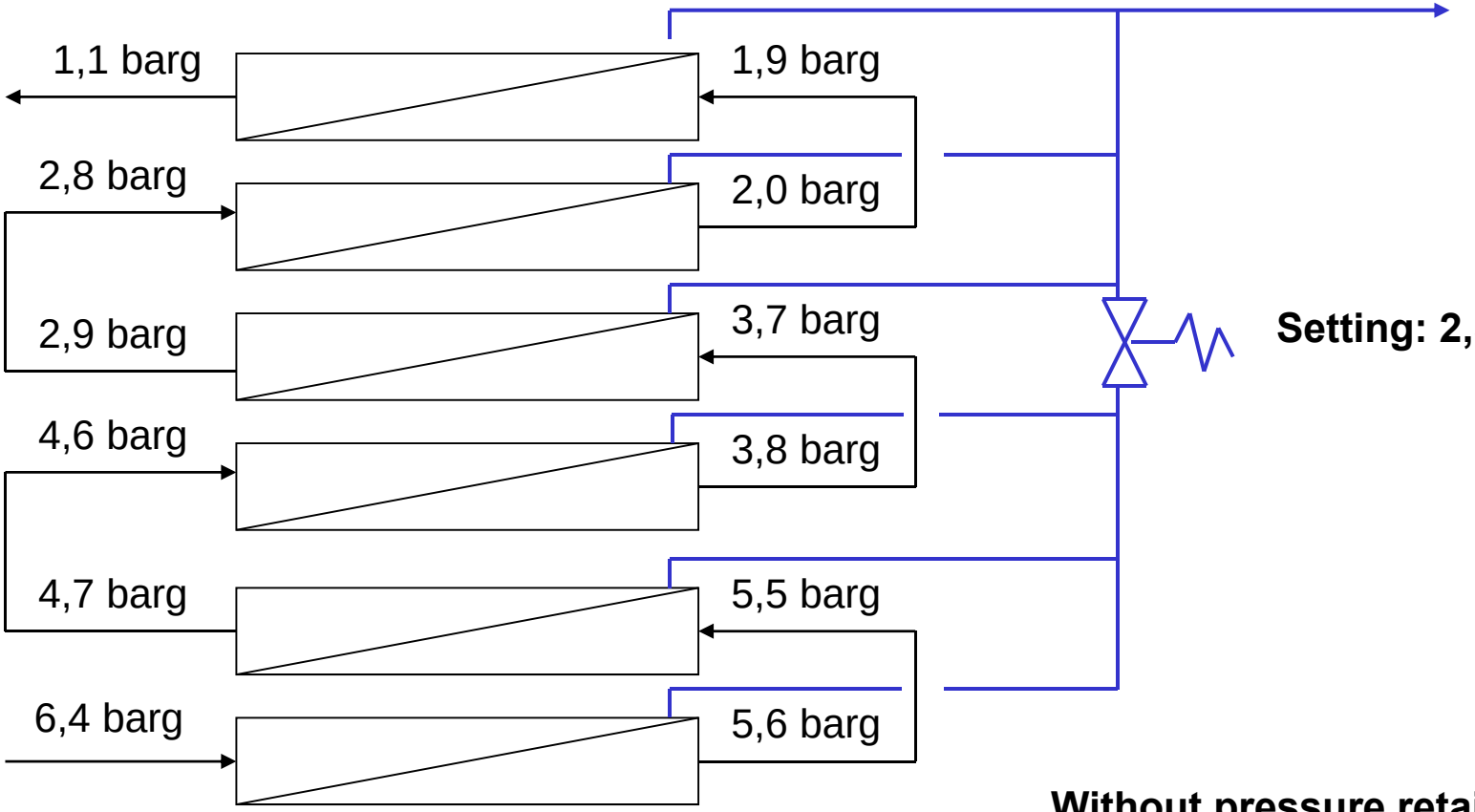
1-16 Consequence of Bad Pre-Screening



1-17 TMP Distribution

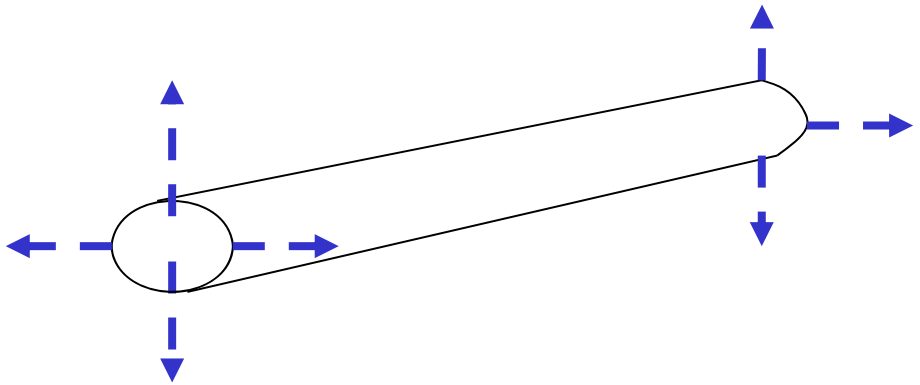


Setting: 2,5 barg

Without pressure retaining valve:

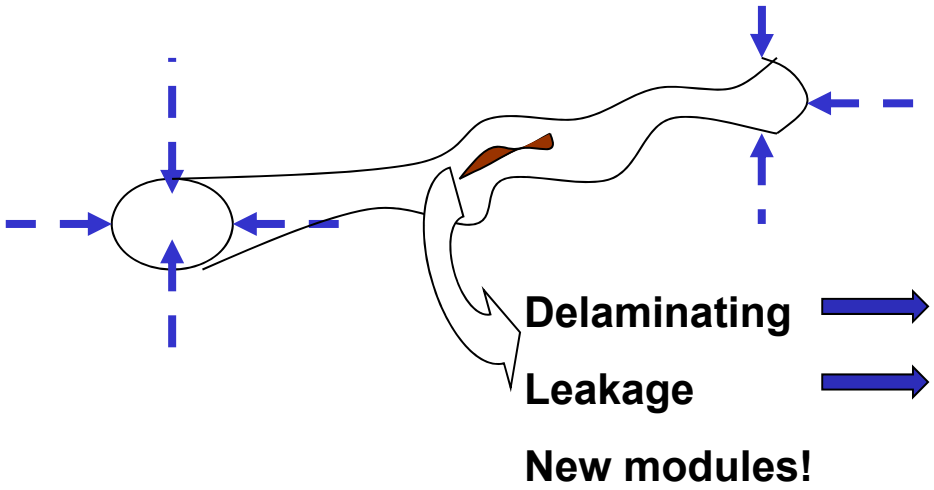
High TMP on bottom modules!!!!

1-18 Effect of Negative TMP



Positive TMP (inside out!:

$P_{inside\ membrane} > P_{outside\ membrane}$



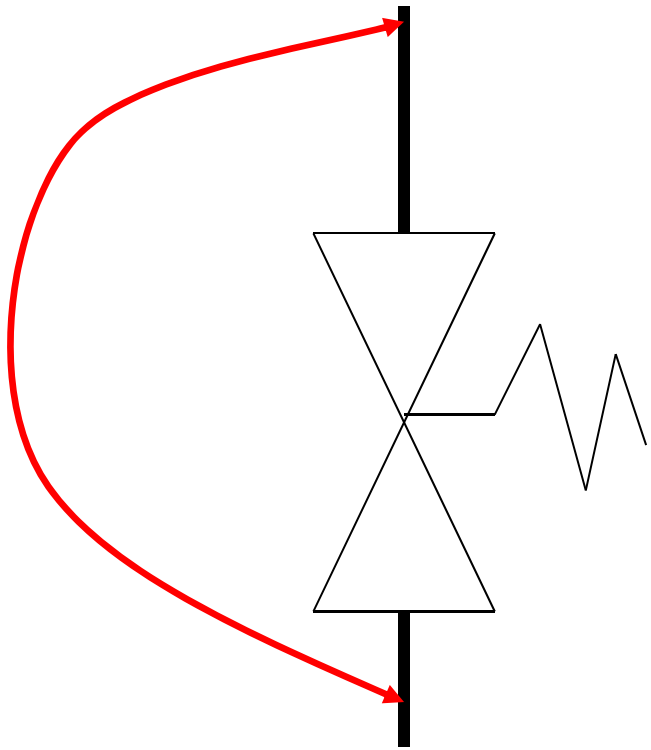
Negative TMP (outside in!):

$P_{inside\ membrane} < P_{outside\ membrane}$

Maximum negative TMP = 0,2 bar.

HOWEVER: negative TMP should be prevented at all time!!

1-19 Prevention of Negative TMP



A small bypass tube prevents negative TMP on bottom modules when UF has been taken out of operation.
(A kind of pressure release)

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2. CF UF PROGRAMS

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2-1 Programs Cross Flow UF

A. Venting program

B. Feed program

C. Filtration program

D. Flushing program

E. CIP program

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2-1A. Venting program

When?

- At first start-up
- After maintenance
- Whenever air is inside the UF membranes

Please notice

The UF membranes must be vented manually before the venting program is started.

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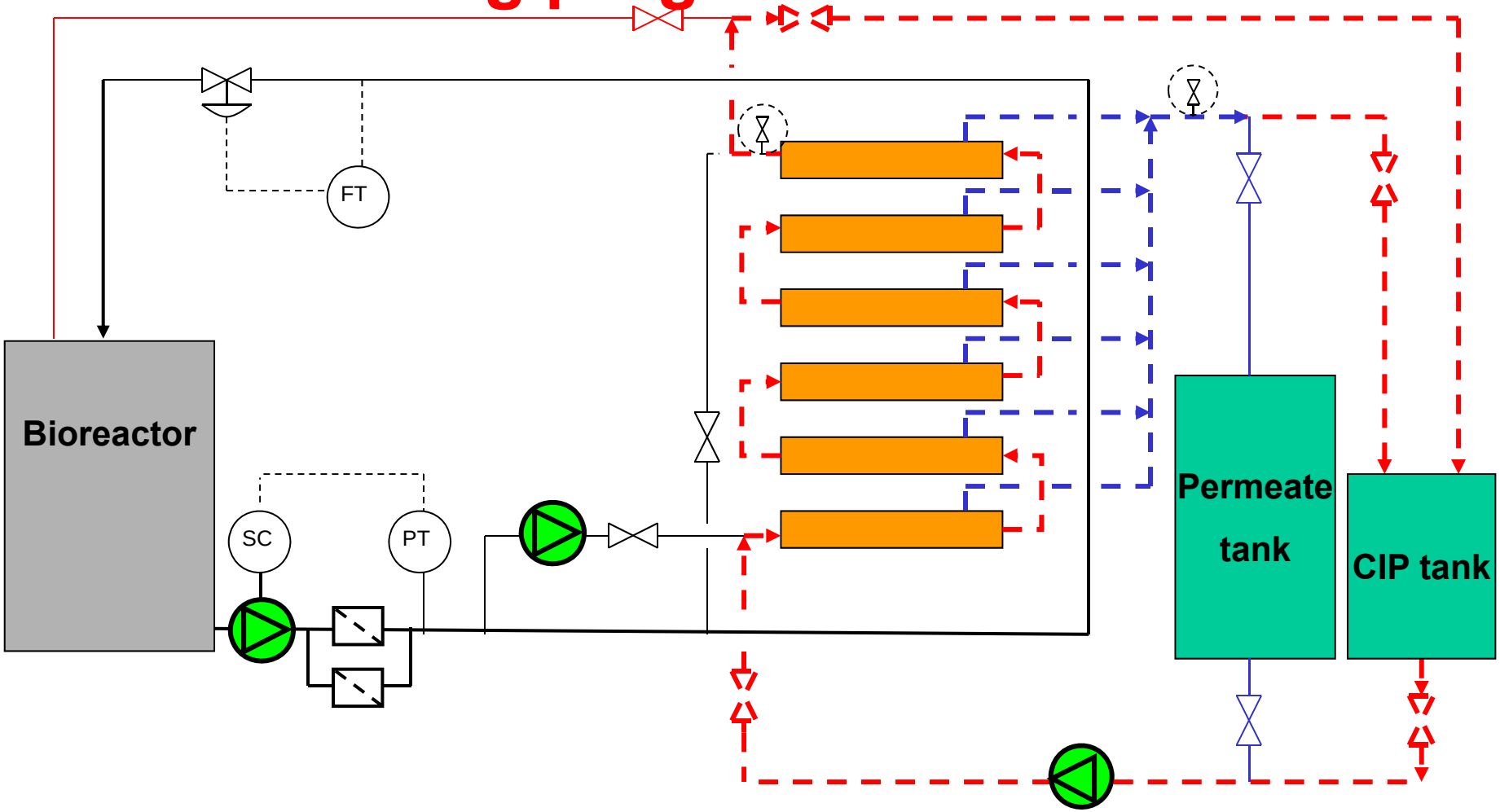
2-1A. Venting program



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2-2 Programs Cross Flow UF

A. Venting program

B. Feed program

C. Filtration program

D. Flushing program

E. CIP program

2-2B. Feed program

When no filtration program is running on the UF units, the UF feed unit is active.

Because:

1. It prevents piping from freezing
2. It prevents sedimentation of biomass
3. It prevents clogging / fouling

When a filtration program is active, the UF feed unit controls:

1. The concentration factor.
2. Pressure of the feed line.

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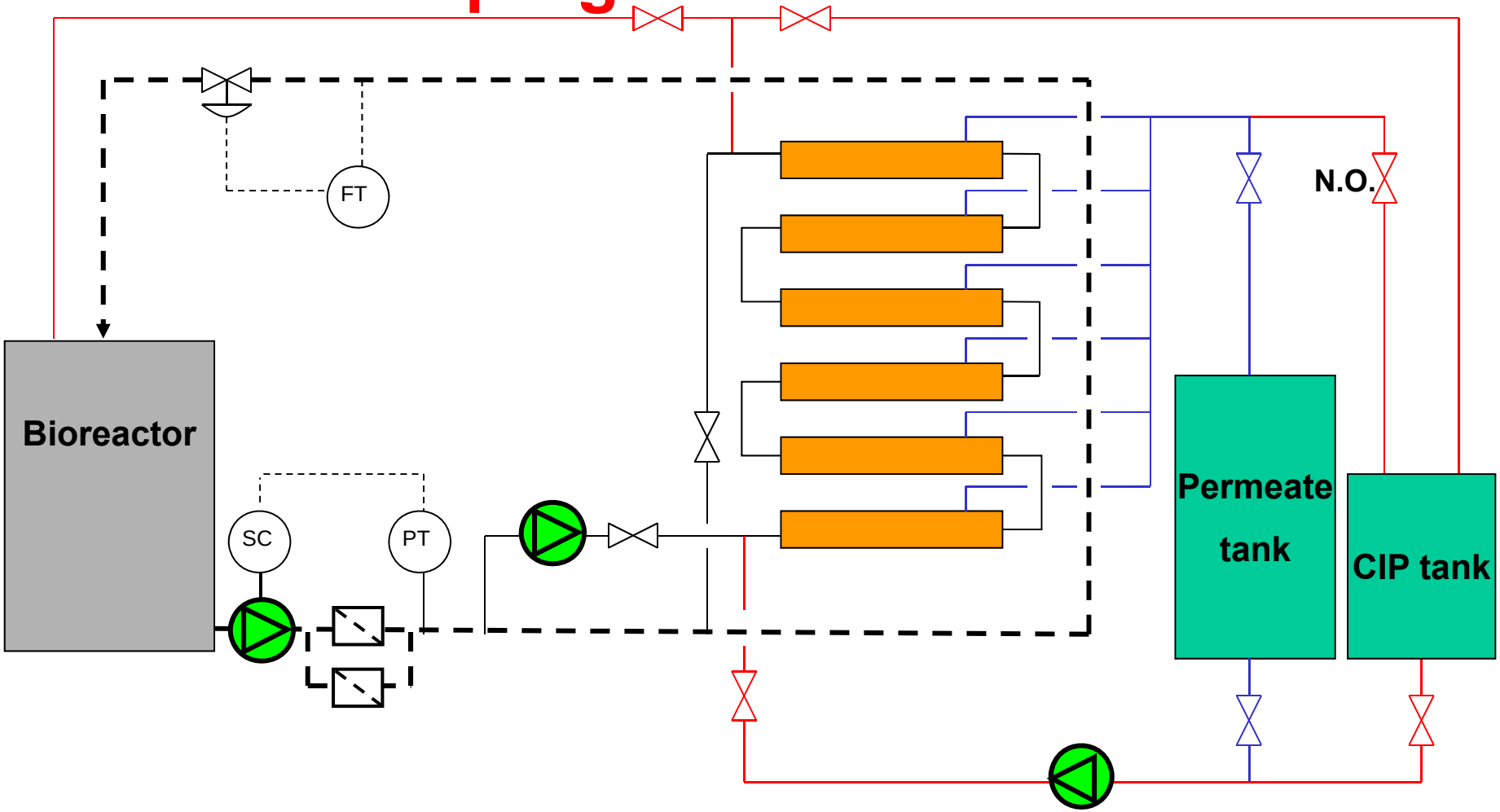
2-2B. Feed program



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2-2B. Feed program

- UF concentrate flow control
  Flow transmitter acting on flow control valve

- UF feed pressure control
  Pressure transmitter acting on the VSD of the UF feed pump

- UF Concentration factor control:
  The feed flow is designed to prevent high concentration factors

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2-3 Programs Cross Flow UF

A. Venting program

B. Feed program

C. Filtration program

D. Flushing program

E. CIP program

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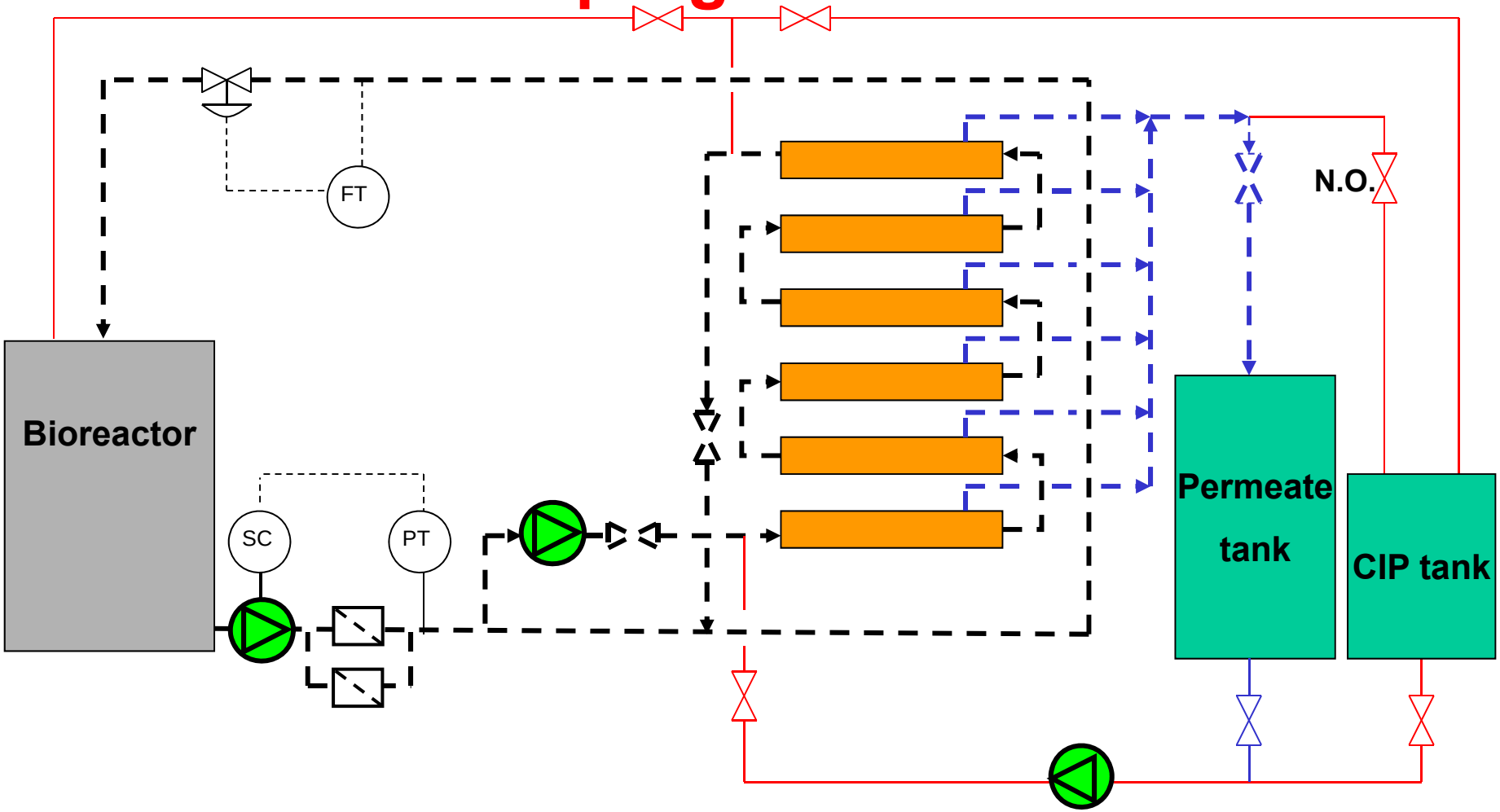
2-3C. Filtration program



2-3C. Filtration program

Important issues related to the filtration program:

1. Prevent dead-end filtration

2 The permeate production can't be controlled! It is depending on the filterability of the medium.

For this reason: the flux used in the design is very important. The flux to use is depending on the application (type of wastewater).

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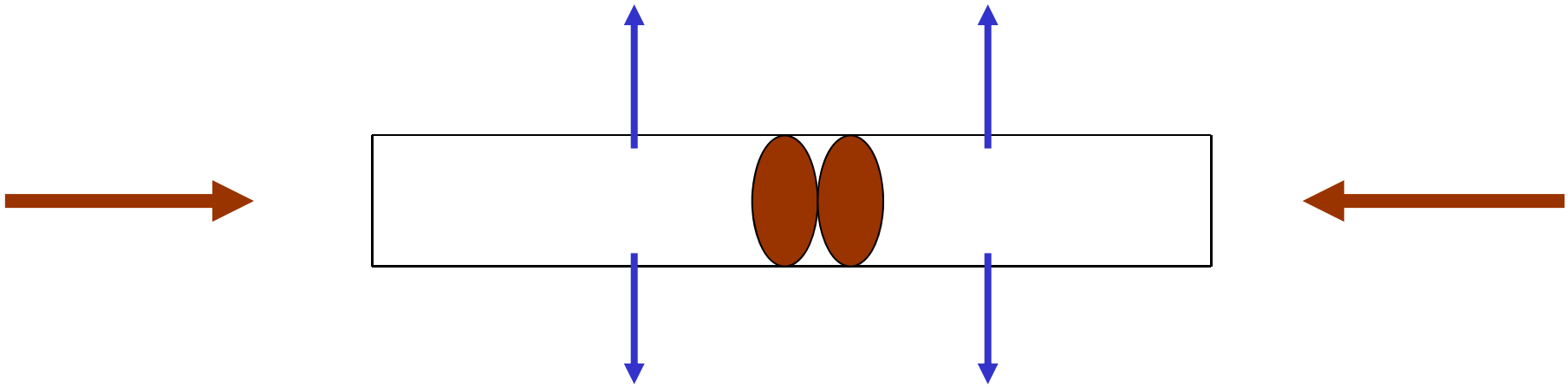
2-3C. Filtration program

Dead-end filtration



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2-4 Programs Cross Flow UF

A. Venting program

B. Feed program

C. Filtration program

D. Flushing program

E. CIP program

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2-4D. Flushing program

Why?

-To flush out built up material.

-To flush out biomass when units are taken out of operation.

When?

- Every single time the filtration program ends or stops.
- Periodically; preventive measure to clean the membranes (runs automatically)
- Periodically; manually initiated (operator initiative)

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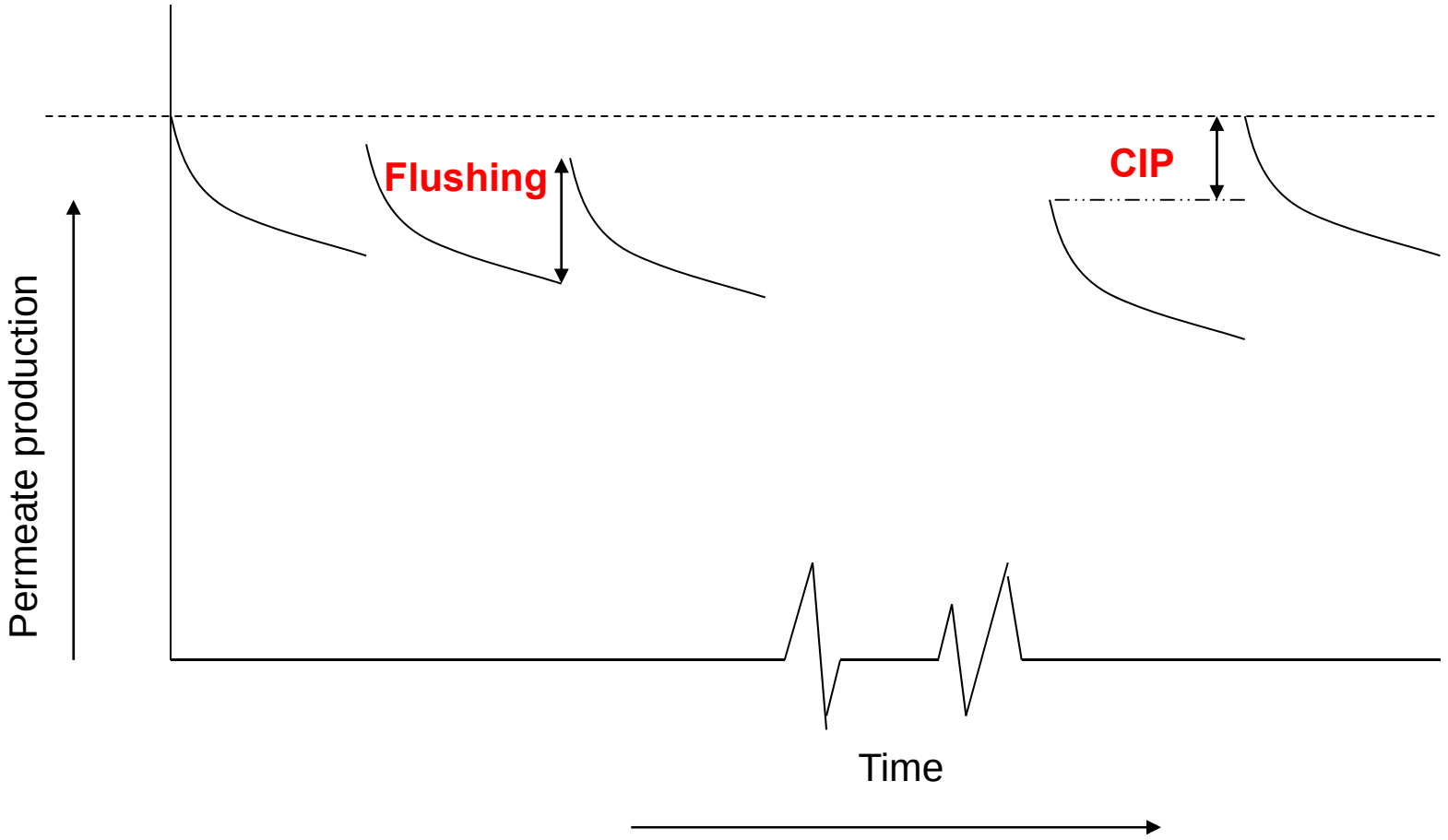
2-4D. Flushing program



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2-4D. Flushing program

Frequency flushing program:

- About once per 24 hours in a stable situation;
- Duration about 1 minute;
- Higher frequency during start-up.

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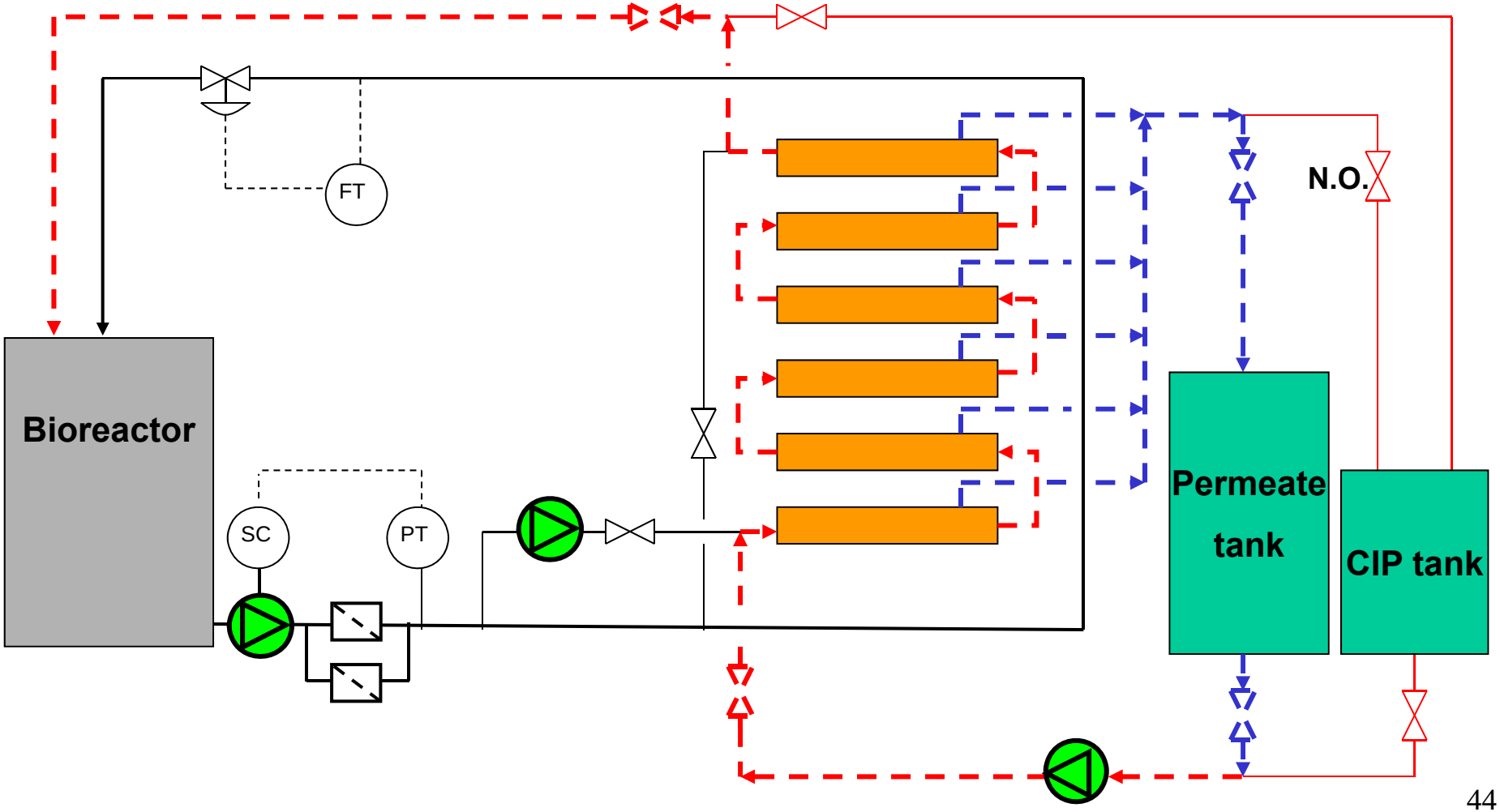
2-4D. Flushing program



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2-5 Programs Cross Flow UF

A. Venting program

B. Feed program

C. Filtration program

D. Flushing program

E. CIP program

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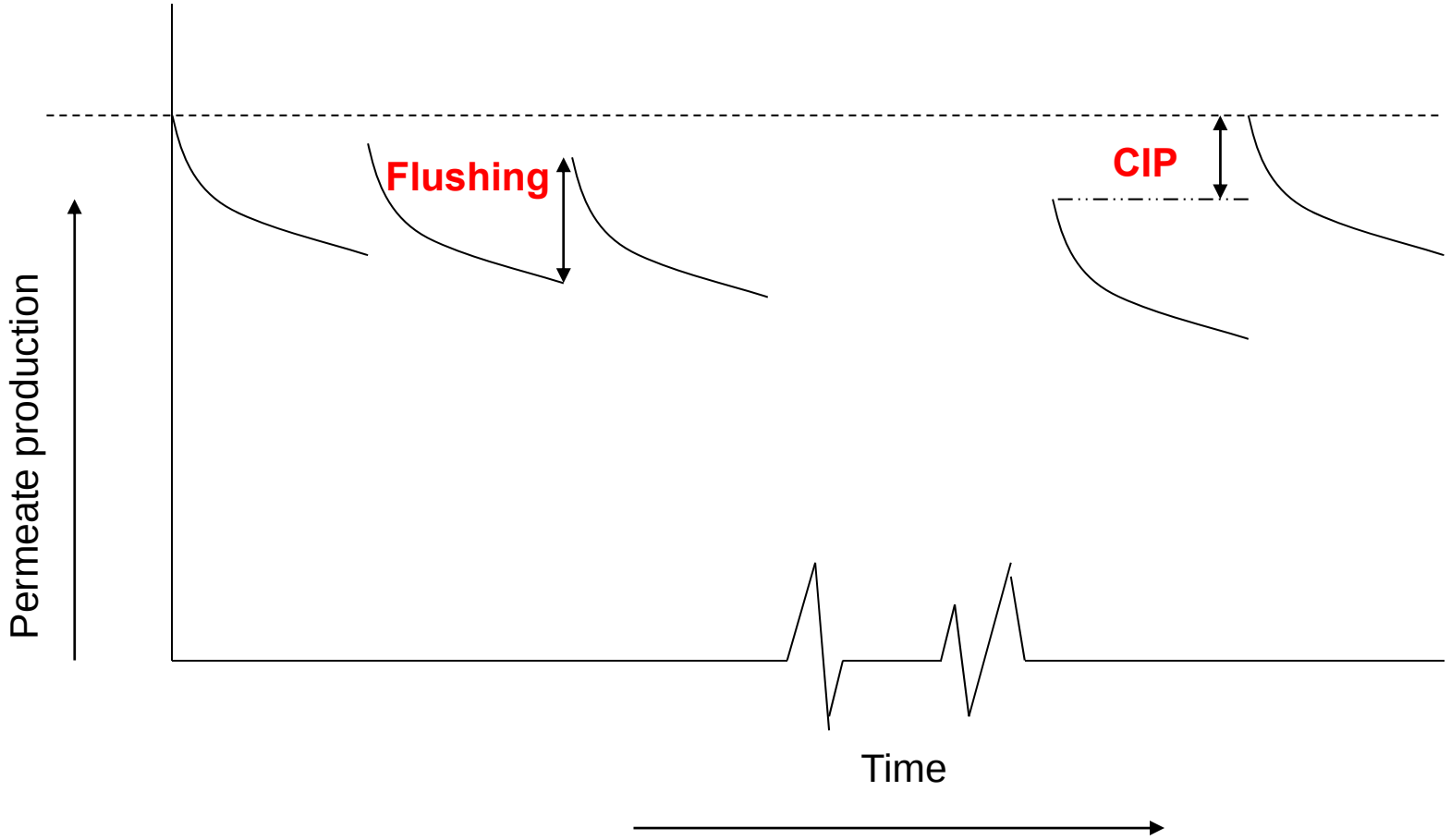
2-5E. CIP program



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2-5E. CIP program

Why?

- Intense cleaning of membranes by use of chemicals

When?

- Periodically; when permeate production has decreased and is not recovered by flushing.

How does it work?

- A CIP solution is prepared in the CIP tank (chemicals).
- The CIP solution is circulated over the skid, modules and CIP tank.
- A soaking period will start.
- Repeating CIP circulation / soaking period.
- CIP solution is directed to sewer system.
- CIP tank is flushed to remove residual chemicals and cleaning products.

2-5E. CIP program

Frequency CIP:

- About once per 2 months in stable situation.

- Higher frequency during start-up and/or for high strength wastewater.

Please notice:

During the CIP program, a “chemical flag” is raised to let the

operator know that chemicals are present.
Prefferably the CIP waste shloud be discharged to the sewer to prevent accumulation of inert matter in the Bioreactor.

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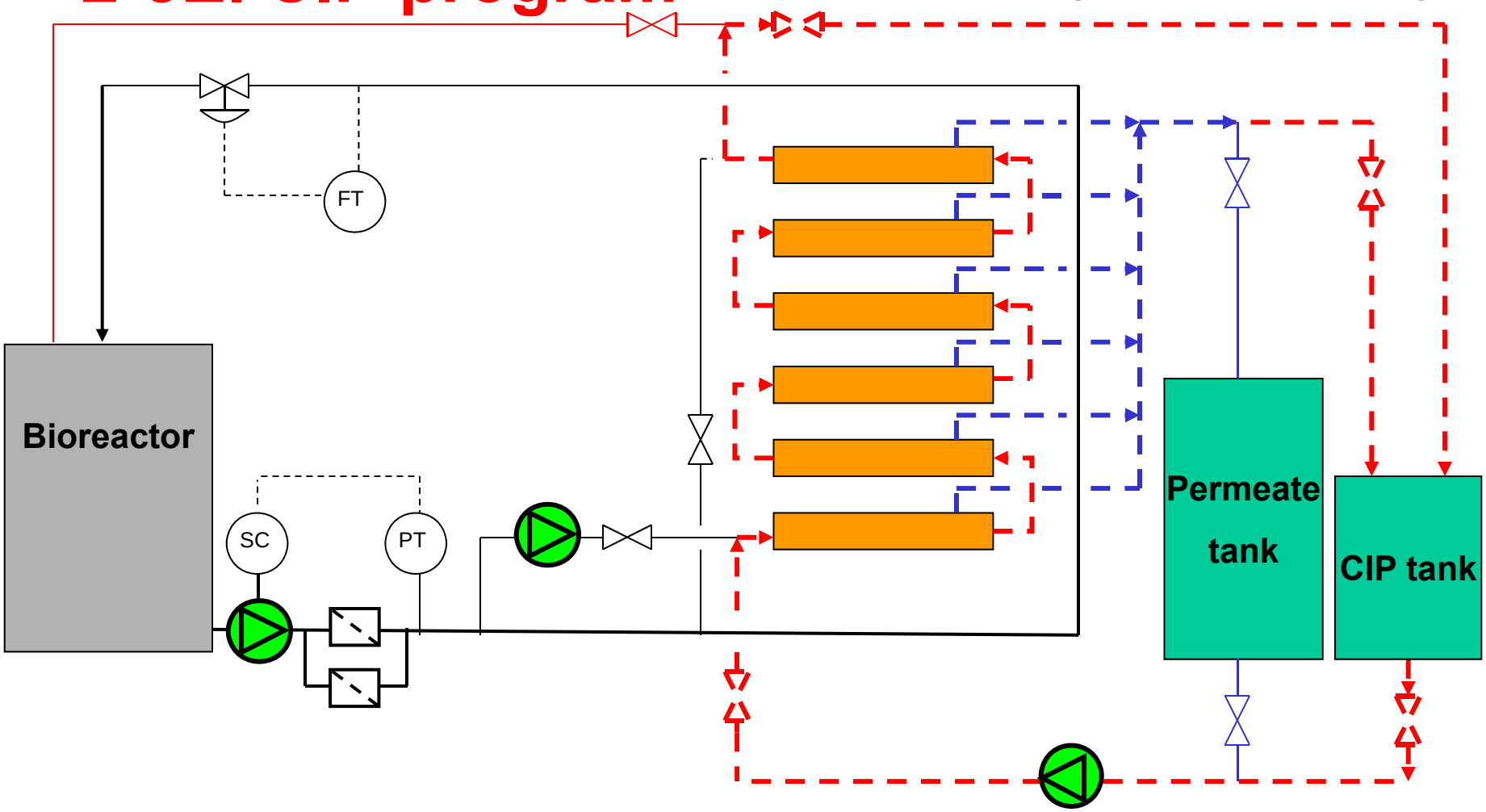
2-5E. CIP program



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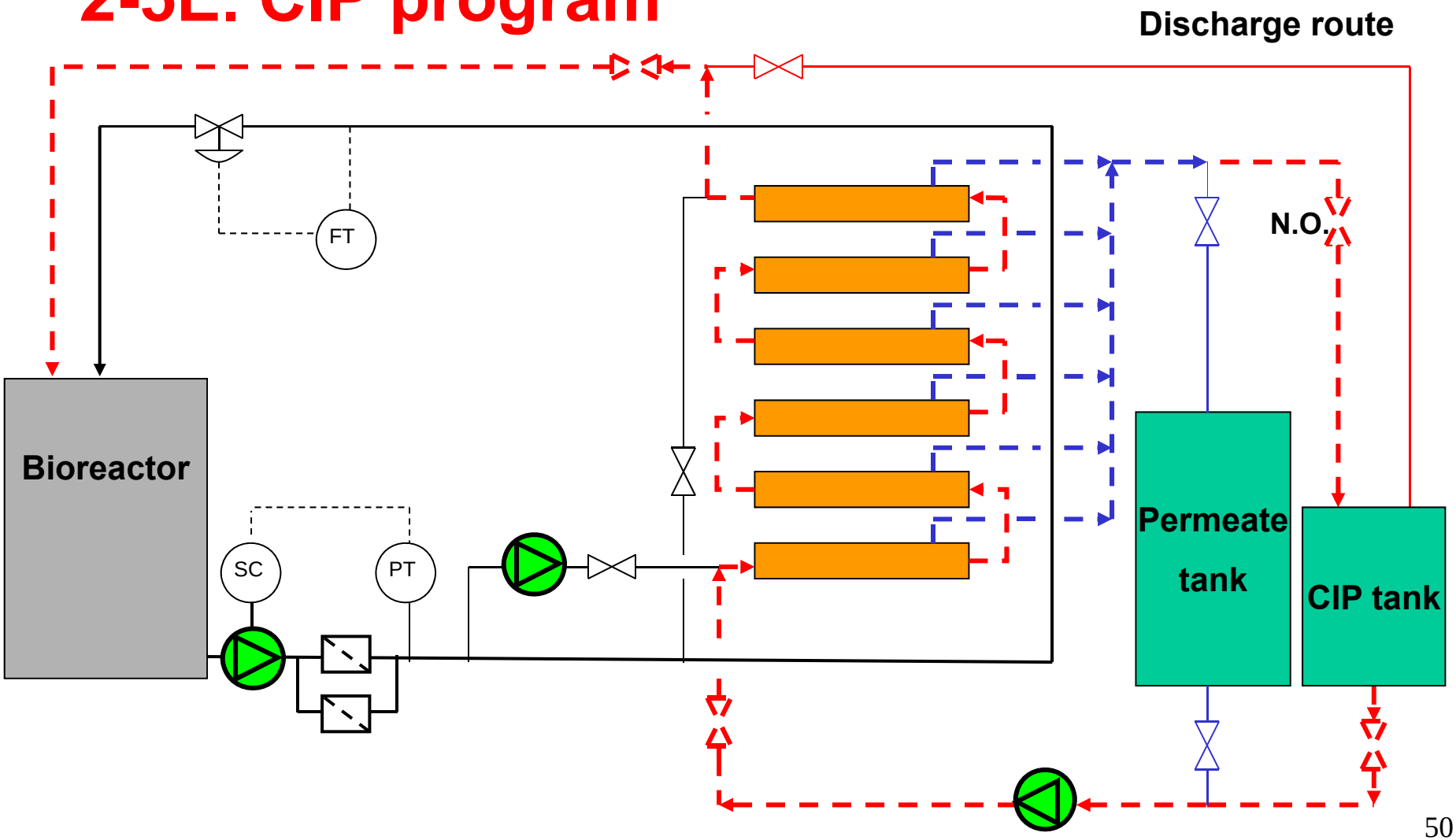
2-5E. CIP program



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3. Type of CF configurations

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Standard Skid configurations:

2 CF Modules

4 CF Modules

6 CF Modules

8 CF Modules

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