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GORO Ni Project

For

Bateman Engineering Ltd

Overhead tanks volume configuration and control

P. Order **No. 12166**

Presented by

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Rockville, 3 June, 2015.

This document contains 14 pages

Summary

This report concludes the work done on:"GORO Ni Project - Overhead tanks volume, configuration and control".

Objective: To calculate and configure the overhead tanks which collect the organic overflow from the various Pulse Contact column batteries.

Assumptions:

- Disturbance is made of two parts: The first is an **"undisturbed"** one and the second one is the **decay** of the same disturbance which is due to the action of the control system (duration of this is referred to as **"Relaxation Time"**).
- The overhead tanks will be operated at a level of 50% as its set point hence **maximum disturbance**, in each set of columns, **can be as big as 50% of the overhead tank volume** of that section;

The dynamic study, prepared with two different approaches, by BATEMAN engineers revealed relaxation time of approximately one minute.

The following results were obtained:

Section	Number of columns	Flow/ Column M^3/Hr	relax time Min	Tank Vol. M^3	L Meter	D Meter
Extraction	7	250.0	2.5	18.75	16	1.5
			2.0	16.67	14	
			1.5	14.58	12	
			1.0	12.50	11	
			0.5	10.42	9	
			0.0	8.33	7	
Scrubbing	4	437.5	2.5	32.81	7	2.44
			2.0	29.17		2.30
			1.5	25.52		2.15
			1.0	21.88		1.99
			0.5	18.23		1.82
			0.0	14.58		1.63
Stripping	8	218.8	2.5	16.41	14	1.5
			2.0	14.58	12	
			1.5	12.76	11	
			1.0	10.94	9	
			0.5	9.11	8	
			0.0	7.29	6	

The design parameters of the system, which are included in the table, are highlighted.

The duration of the "undisturbed" disturbance and the decay time are both design parameters of the system and we recommend to use one (1) Minute for the "undisturbed" flow time and one (1) Minute for the relaxation time. This will assign the overhead tanks with sufficient volume.

In configuring the Overhead tanks we found the "Cylindrical Horizontal" simpler to connect to all, present and future, overhead solvent connections. Maximum length was used for these tanks in each case accordingly - allowing minimum space to let safe and ease of access to the tank from all directions.

The resultant Calculated "diameter" for the Stripping and Extraction, though do fulfill the volume requirements – might bear some problems due to higher turbulence inside the tanks. For this reason wider tanks, which reduce the flow velocity, are recommended for these sections and impingement plates to be installed inside all the tanks – to reduce turbulence.

To minimize the risk of "shocking" the organic solvent, we offer a modification/addition to the **Organic Solvent Flow Control System.** This modification will dynamically tie changes in throughput down the production sequence (Feed Forwarding), with appropriate dynamic compensation (Lead/lag) to avoid flooding or drying of solvent tanks and lines. Using the organic levels as flow trimmers can smooth the overall operation.

Operation instructions are/were posted as a reminder to operators of the importance in adjusting organic solvent flow feed to all sections with the proper dynamics of the plant.

Some alarms should be configured into the DCS to help operators making out abnormal or risky situations.

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The mission

"GORO – NI Extraction Project" is designed to operate 19 pulse columns, 7 extraction columns, 4 scrubbing columns and 8 stripping columns. Each set of these pulse columns is equipped with an overhead tank which collects the columns overhead organic solvent overflow.

For safety reasons it is necessary that the pipes, which connect the overflow of the columns to either the solvent tanks or to the scrubbing columns, are run fully flooded in order to prevent the entrainment of oxygen. Static electricity which is generated by the non conductive solvent may result in an fire or explosion in presence of this.

Organic solvent flow speed in either section of the unit should never exceed one (1) $^{M}/_{Sec}$.

It is essential to maintain the level in the intermediate tanks between safe limits, in order to ensure that the feed pipes are always fully flooded and no solvent is lost to drainage

It is necessary to find:

- The minimal residence time required for insuring a proper control of the tanks' level.
- The proper configuration of the tanks (horizontal or vertical) and their dimensions.

Assumptions and Calculations

BATEMAN engineers (Messrs I. Kenner and A. Efraim) studied the dynamic behavior of the organic solvent flows and levels and found the relaxation time to be around the one minute mark.

Assumptions:

(a) No problems will develop from interference of the columns pulsations;

(b) Tanks will be operated with a level of 50% as their set point;

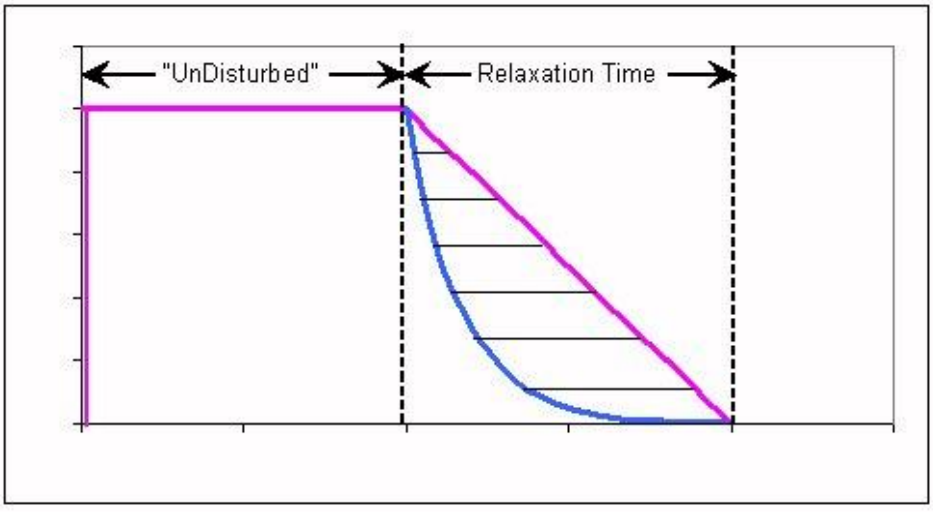
(c) Tanks' level is allowed to change ±50%;(e.g. – Tank levels will be allowed to vary between 0% and 100%)[1];

(d) For ease of connection to columns overhead **Cylindrical Horizontal** format will be used. These will occupy the maximum length available in each case[2] - allowing minimum space to let safe and ease of access to the tank from all directions;

(e) System is designed for a flow of 1750 $M^3/_{Hr}$ organic solvent;

(f) Maximum disturbance is caused when a column is added or subtracted from operation. Magnitude of the disturbance (worst case!) will be $^1/_n$ 1750 $M^3/_{Hr}$ (n – number of columns in each battery).

(g) Disturbance is made of two parts: The first is an "**undisturbed"** one and the second one is the **decay** of the same disturbance which is due to the action of the control system (duration of this is referred to as **"Relaxation Time"**).



This is a qualitative presentation of the real disturbance (blue line) and the assumed disturbance (magenta line) the distance between these is our severed approach.

[1] See "Instrumentation" in "Operations Instructions" page 12.
[2] See "Results" page 8.

Calculations

Maximum Disturbances

(1) Extraction $V_{Extr} = 1750/7 = 250 M^3/Hr$

(2) Scrubbing $V_{Scrb} = 1750/4 = 437.5 M^3/Hr$

(3) Stripping $V_{Strp} = 1750/8 = 218.8 M^3/Hr$

Assuming **"undisturbed"** of t_1 minutes and linear decay[3] for t_2 minutes, (relaxation time,) then the total accumulated liquid will be

(4) $Disturbance Volume = V \times t_1 + \frac{V \times t_2}{2}$

Where t_1, t_2 and V (Disturbance in flow) are in the proper units (e.g. $M^3/_{Hr}$ and Hr or $M^3/_{Min}$ and Min).

(5) According to Assumption (c)
$Tank\ Volume = Disturbance\ Volume \times 2$

(6) Following assumption (d), (maximum) length of tanks will be:
L_{Extr} = *21M* Total length available is 28 Meters.
L_{Scrb} = *7M* Total length available is 14 Meters.
L_{Strp} = *21M* Total length available is 28 Meters.
This will allow minimum space to let safe and ease of access to the tank from all directions.

(7) The Diameter is calculated accordingly:

$$D = \sqrt{\frac{4 \times Tank Volume}{Length \times \Pi}}$$

(8) Minimum allowable tank diameter is derived from the flow speed restriction of ***one (1)*** $^{M}/_{Sec}$ ***(V)***. For the given flow of ***1750*** $M^3/_{Hr}$ ***(F)***, With ***50% (L)*** normal operating volume, with ***Center*** tank outlet (which divides the active flow by 2):

$$D = \sqrt{\frac{F \times 4}{2 \times L \times 3600 \times \Pi}} = \sqrt{\frac{1750 \times 4}{2 \times 0.5 \times 3600 \times \Pi}} = 0.79 Meter$$

[3] Real decay will be Exponential which is faster. Linear is more severe assumption. See above illustration.

Results

Highlighted numbers are controlled variables.

	Number of columns	Flow/ Column M^3/Hr	Un disturbed disturbance volume M^3	relax time Min	Ramp Down volume	Dv M^3	Tank Vol. M^3	L Meter	D Meter
EXT	7	250.0	4.17	2.5	5.21	9.38	18.75	21	1.07
				2.0	4.17	8.33	16.67		1.01
				1.5	3.13	7.29	14.58		0.94
				1.0	2.08	6.25	12.50		0.87
				0.5	1.04	5.21	10.42		0.79
				0.0	0.00	4.17	8.33		0.71
Scrubb	4	437.5	7.29	2.5	9.11	16.41	32.81	7	2.44
				2.0	7.29	14.58	29.17		2.30
				1.5	5.47	12.76	25.52		2.15
				1.0	3.65	10.94	21.88		1.99
				0.5	1.82	9.11	18.23		1.82
				0.0	0.00	7.29	14.58		1.63
Stripp	8	218.8	3.65	2.5	4.56	8.20	16.41	21	1.00
				2.0	3.65	7.29	14.58		0.94
				1.5	2.73	6.38	12.76		0.88
				1.0	1.82	5.47	10.94		0.81
				0.5	0.91	4.56	9.11		0.74
				0.0	0.00	3.65	7.29		0.66
Equations Reference		(1), (2), (3)				(4)	(5)	(6)	(7)

The duration of the “undisturbed” disturbance and the decay time are both design parameters of the system and we recommend to use one (1) Minute for the first (“undisturbed”) and one (1) Minute for the relaxation time and to assign the overhead tanks with sufficient volume.

The resultant Calculated “diameter” for the “Stripping and Extraction, thou do fulfill the volume requirements – might bear some problems due to higher turbulence inside the tanks. For this reason wider tanks, which reduce the flow velocity, are recommended and impingement plates to be installed inside all the tanks – to reduce turbulence.

Lengths of tanks were selected according to the available space in the case of the scrubbing battery and as derived from selecting the “wider” tanks in the Stripping and Extraction sections.

The following table summarizes our recommendation for the implementation of these "Overhead Tanks", as was set forward in BATEMAN's request.

Section	Number of columns	Flow/ Column M^3/Hr	relax time Min	Tank Vol. M^3	L Meter	D Meter
Extraction	7	250.0	2.5	18.75	16	1.5
			2.0	16.67	14	
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			1.0	10.94	9	
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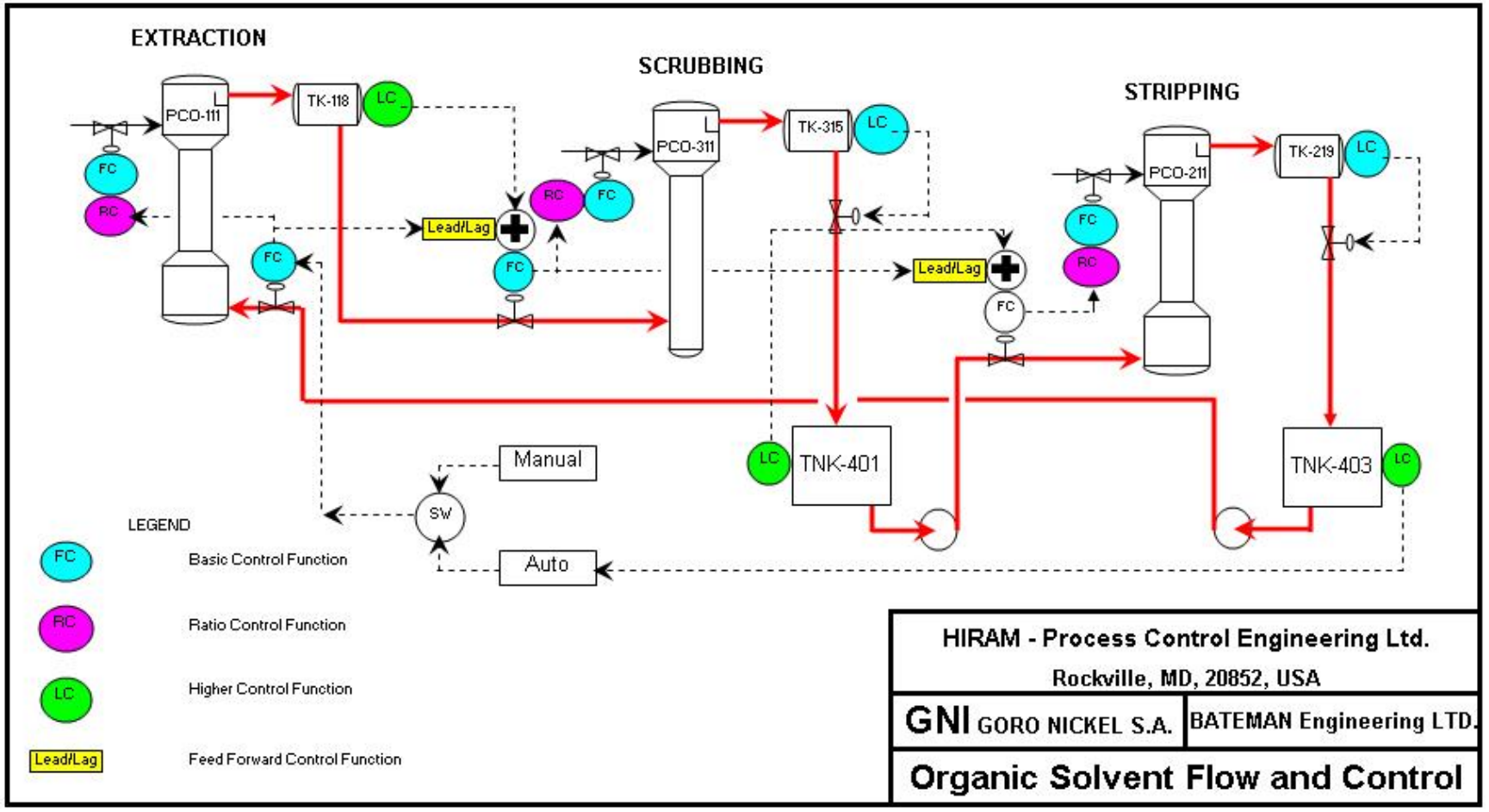
			0.0	7.29	6	

As can be seen wider tanks are selected for the Extraction and Stripping sections and the required length is "back calculated".

Process Control



To improve operation and to minimize the risk of "shocking" the organic solvent, some modifications/additions are offered to the **Organic Solvent Flow Control System.**

Originally the unit was designed with basic controls to take care of the **flows** and **levels**. Aqueous streams were tied to the organic feed to each column with **Ratio Flow control** algorithms.

To avoid dry out of the lines coming out of Tank 315 and Tank 219 Level controllers were installed. Level controller in Tank 118 manipulates the feed to the Scrubbing section to achieve the same goal. These Level Indicator Controllers (LIC's) also prevent flooding of these tanks and the pulse columns as well.

It is recommended to install LIC's on Tank 401 and on Tank 403 as well. The output signal from Tank 401's LIC will be used to change the organic flow into the Stripping section. The output signal from Tank 403's LIC will be available to control the organic flow into the Extraction section in steady state operation. (The Feed Forward has to be broken on this one whenever a change of throughput is required). The system is designed with very small spare volumes hence the operation should seek the safe steady state all the time. This feedback will smooth the operation and will also protect the system from instrumentation errors.

Possibility of flooding or drying of solvent tanks and lines can be drastically reduced by feed-forwarding the changes in organic feed flow into any of the sections, with the proper dynamics, to the organic feed flow into the following section, from the extraction section into the Scrubbing section and from the Scrubbing section to the Stripping section. These are implemented by using the "Lead/Lag" algorithm which is available in all modern DCS's and will ensure smoother operation and bland transitions – if and when needed.

The outputs of the LIC's and the "Lead/Lag" ate combined at the entrance to each of the organic solvents feed flow controllers.

In implementing this strategy, attention should be given to controllers tuning parameters

General highlights

Operations Instruction

Though it is obvious, the importance of integrated control of all plant parameters, without going into performance variables, should be covered in the operators' instructions.

It is true that sudden interrupt in operation (e.g. column cut out in any section) should not cause any problems, it is strongly recommended that plant procedures will cover this case and that operators will be knowledgeable about this situation and will know how to best react to it.

We can see no reason to include "column cut in" as a problem of this type, as we do not expect columns to "jump" into operation on their own…

Instrumentation

LIC's of these tanks should be mounted on the farthest point possible from their drains, thus allowing for minimum noise while measuring the solvent level inside these tanks.

Attention should be given to level indication setting. Instrument 0% and 100% reading can be calibrated arbitrarily. The instrumentation engineer should be instructed to the designer's preference. (No recommendation is made as we are not fully familiar with plant operation concepts.)

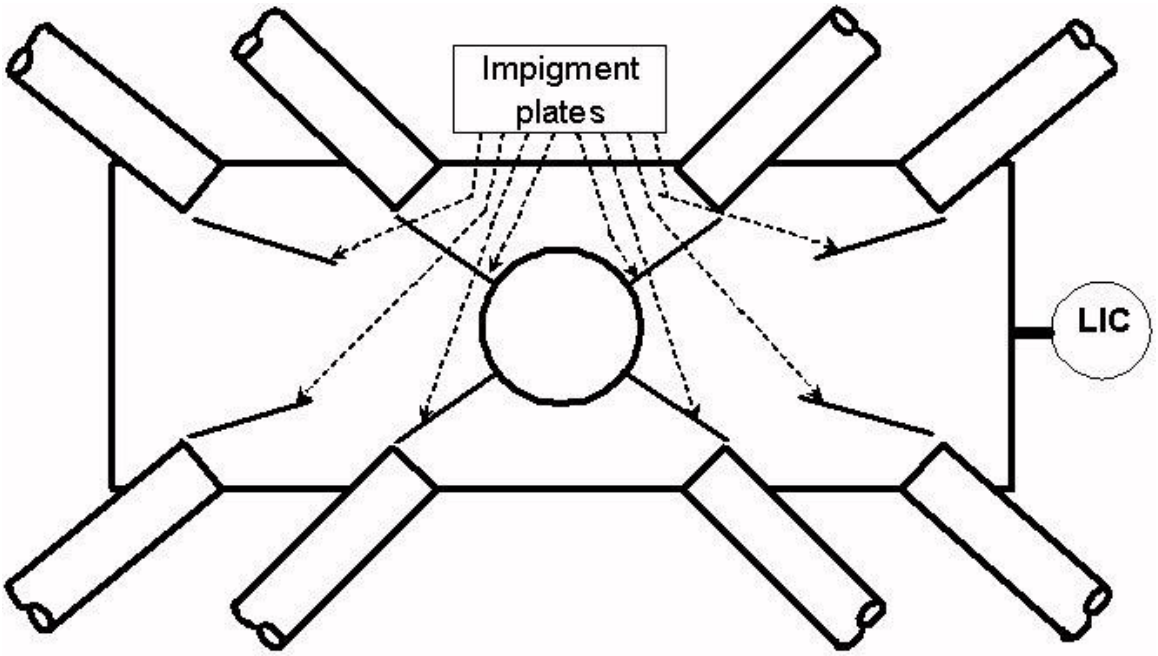
Alarms and **Warnings** have to be set within the DCS to help operators make out irregular or dangerous situations.

Tank Design

We recommend building the tanks as horizontal cylinders.

The lines collecting the columns overheads should be evenly distributed around the tank circumference.

Central drain will effectively divide the flow at each section to half of the total flow into this over head tank which is the total circulating solvent flow in the system.

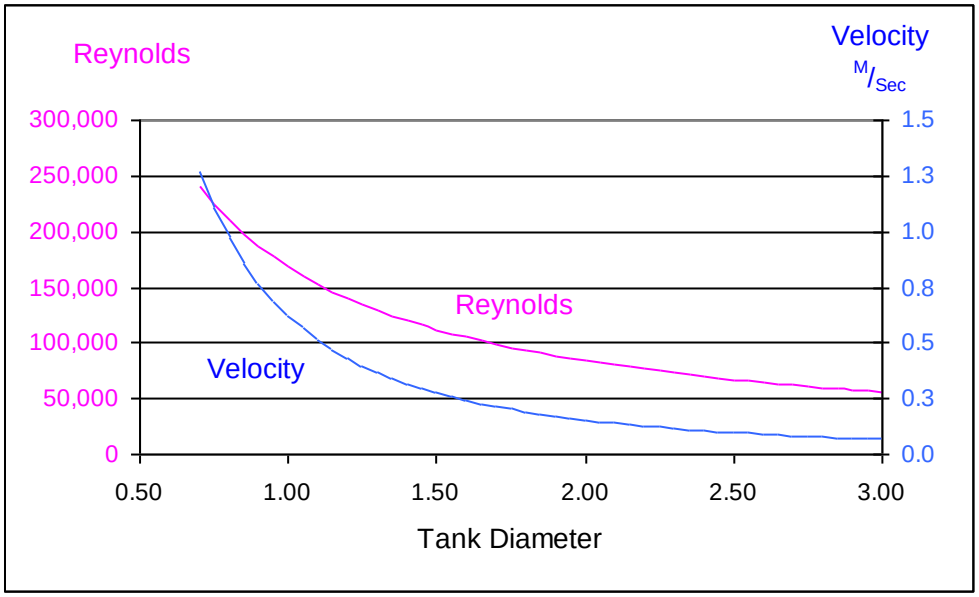


This is a schematic sketch of an overhead tank, assuming eight lines entering:

- Entering lined are directed toward the center drain;
- Impingement plates are extended from the bottom to the top of the cylindrical tank. These are to direct the liquid toward the exit and serve as vortex breakers as well. All this to reduce the turbulence;
- **LIC** will be mounted as far as possible from the drain, assuming an area of relative calmness – to allow better indication of the level

Over Head Tank Flow Pattern

The following figure demonstrates the relation of flow velocity to tank diameter.



Increasing the tank diameter reduces the flow velocity, which in turns reduces the Reynolds number.

In spite the fact that we stay in totally turbulent regime of flow, we expect much better "behavior", especially of the instrumentation.

(Calculations on which this figure is based are available in the attached XLS file, in the "Reynolds" tab.)