COMOTI
ROMANIAN RESEARCH & DEVELOPMENT INSTITUTE FOR GAS TURBINES
Lead partner

Ruse UNIVERSITY
Angel Kanchev
Partner

Common strategy to prevent the Danube's pollution technological risks with oil and oil products - CLEANDANUBE

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STUDY 5

Execution details of the new purification solutions of the water infested with oil products

Working team:

Lead partner: National Research & Development Institute for Gas Turbines COMOTI Bucharest, Romania

Puscasu Cristian
Stefanescu Mariana
Voicu Raluca
Axene Ghita
Grigorescu Mihaela
Adam Liviu
Cretu Mihaela
Precob Luminita
Toma Emilian
Teleaba Victoria
Antonescu Marilena

Partner: University of RUSE "ANGEL KANICHEV", Rouse, Bulgaria

Ivanka Mitkova Zheleva
Klimentov Kliment
Nikolaev Ivaylo
Popov Gencho
Russev Piter
Tuzharov Krasimir
Panteleeva Yana Kraleva
Kopchev Peter

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Study no.5

Execution details of the new purification solutions of the water infested with oil products

5.1 Introduction

In this study aims to define standard and auxiliary elements that goes into water infested with petroleum products treatment plants and the development documentation of detailed execution.

Auxiliary devices that goes into the system are according **Study no.3, fig.5** following:

-Protective-barrier systems(dams);

-Infested water collection system;

- Drives a centrifugal separator plant;

-The storage system of processed products;

-Instrumentation and control of technological process.

Figure 5.1 shows the general configuration of a plant for recovery of oil spilled into the Danube resulting from the studies included in this project.

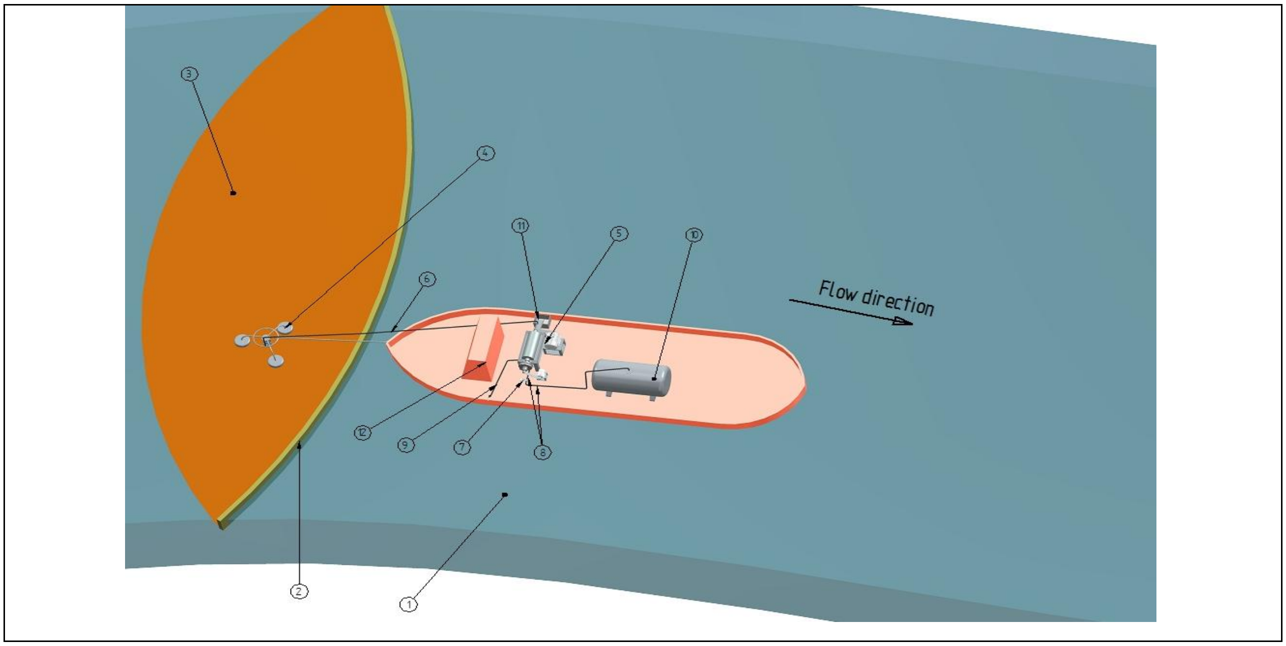


Fig. 5.1 Overview of an ship-mounted installation for the recovery of petroleum products spilled in the waters of the Danube.

1. Danube river;
2. Protective-barrier systems;
3. Wastewater;
4. Infested water collection system;
5. Centrifugal separator assembly;
6. Infested water pipe;
7. Oil pump;
8. Recovered oil pipeline;
9. Water discharge pipe;
10.Oil tank;
11. Solids collection tank;
12. Control panel

In the following it will focus on sizing the plant elements, functional characteristics and their role in the process. It also will define the instrumentation and control equipment of the technological process, using the latest technologies.

5.2 Protective-barrier systems

The use of anti-oil aims enclosure / insulation of a polluted areas for:

- Preventing uncontrolled spread and displacement of hydrocarbons on the surface:
- Maintaining a strictly delimited area of oil film:
- Promote oil recovery operations (reducing the spreading surface and increasing of film thickness);
- Directing the film to the recovery equipment:
- Protection of vulnerable areas, sensitive.

There are a variety of dams made so far, both in construction point of view and in terms of working conditions and possibilities of use.

In order to select the most suitable type of dam, both in the acquisition phase as and the use is necessary, as needed, all variants of constructive knowledge under the existing classifications.

Multifunctional structure of each type is evidenced by the classification criteria, in close connection with the method which belongs to:

Arrangement to the water surface (area of operation)

- Surface dams;
- Bottom dams

The surface dams acts on floating on water hydrocarbon and the bottom dams acts on hydrocarbons arising from an underwater source (broken pipe, the ship sank, rash below the water).

After working conditions, dams can be:

- For flowing water (rivers, streams, canals):
- For calm waters (lakes, sheltered bays, basins and aquatic port);
- For open sea (offshore).

The differences consist in constructive form, tensile characteristics and mode of anchoring.

After the way of use, the dams can be:

- Liabilities, used in a permanent or static mode (for chronic pollution);
- Assets, used in dynamic mode (for accidental pollution).

The passive ones, sometimes called stationary, have a fixed site in the film way, while the assets ones are used dynamically, driven by ships in various trawl systems.

After how the barrier effect is achieved (in fact, after working principle) dams can be:

- With fluid jets;
- With floating elements.

In their turn, dams with jets of fluid can be:

- With air jets;

- With surface water jets;
- With curtain of air bubbles, under the water.

About floating dams, by far the most used category, they can be:
- Rigid float floating dams (built);
- Inflatable floating dams;
- Autogonflabile floating dams;
- Fireproof dams;
- Off-hand dams

Technical and functional characteristics of floating dams

- **Description:**

Anti-oil floating dams are presented as a continuous curtain, so arranged:

The freeboard is the emersion, floating part, which does not allow the movement of the pollutant on water surface. In the end, the freeboard's aim is to permanently tracking the wave in providing the system's floatability**.**

The Skirt is the immersion part, which does not allow the movement of the pollutant in the water mass, under the dam.

The Ballast chain maintains the dam in a vertical position (to keep Jupa in lying position).

The section is a portion of a certain length of dam (to obtain a length of tens and hundreds of meters is necessary the coupling of multiple sections).

Quick coupler is a metal system which rapid joining several sections.

Anchors, cables for hauling or fixing is the auxiliary system which hauling or fixing the entire dam.

- **Technical**

The need for use in areas, conditions and different ways imposed the achievement of the dams in different range in terms of technical and dimensional characteristics.

As technical features can be listed:

Tensile strength - is the tensile strength at break of the system which function in both conditions static and dynamic

Weight/ meter - is the weight of the system: Freeboard /Skirt / chain / compounds per meter:

UV resistance - is the material's resistance (constituting the freeboard and Jupa) to the action of UV radiation.

Characteristics of the dams should be correlated with hydro-meteorological operating conditions:

	Offshore		For shore and harbor		
Freeboard (mm)	1300	600	400	300	200
Skirt (mm)	1500	1100	600	500	300
Weight of ballast chain (kg/m)	36	17	6	5	4
Tensile strength (kN)	400	200	100	90	50
Maximum wave height (m)	6	4	3	1,5	0,5
Stabil in curent$_{maxim}$ (Nd)	3	2	2	2	2

- **Functional features:**

Functional characteristics are all limited parameters in which the system can work effectively;

Wave height (maximum) - is the maximum wave height (calculated from water surface) at which the dam does not allow the pollutant passing over it.

Flow Stability (max) - is the flow speed in which the dam remains upright and not allows to the pollutant to slip under Jupa.

Wind power (max) - is the maximum wind limit in which the dam resist in terms of tensile strength.

Temperature - the temperature limits within the dam material maintains its characteristics so they can resist and function efficiently.

Mod / storage space - is the volume that is occupied by dam when it is stored in the warehouse.

Location operation/ development position - is the amount of human and material effort and the time for mounting the dam in the working position.

- **Materials used in dam construction:**

Given the tough operating conditions presented and permanent contact with the oil, it is necessary to use "express materials" to build the dam, as follows:

Freeboard and Skirt - can be made of:

- Textile PES / PA coated with special rubber or PVC (flexible, do not rot, tensile strength, UV resistant, resistant to the action of oil, do not exfoliate; they are just a few required features).
- Rubber bands:
- Flame retardants;
- Sheet of steel.

Floating - can be made of polyethylene, polyester, cork, fiberglass, foam expanded, sheet of steel, fabric coated with rubber / PVC:

The chain - can be made of galvanized steel, stainless steel, etc;

Coupling - can be made of galvanized steel, stainless steel, fiberglass, etc;

In the attached presentation made in PowerPoint format are shown several representative types of floating dams, as follows:

- Rigid float floating dams (built)
- Rigid float floating dams (attached);
- Traction cable dam:
- Autogonflabile floating dams;

- Inflatable Floating dams;
- Fireproof dams;
- Off-hand dams.

The use of antipetrol dams

In order to limit the concentration (increasing the film thickness of pollutant) or reorientation of oil displacement in a certain direction, the dams can be passively or dynamically used.

a. The dynamic way is to tow (trawl) the dams on a route determined in advance. The success of such operations depends on tugs used. They must be strong enough and maneuverable that it can pull about 300-800 m of dam at speeds of around…..

Generally it is estimated that 1 CP of motor is equivalent to 20 kgf traction. Ships with two variable pitch propellers, type trawl fish are easier to handle. Towing ropes must have a minimum length of 50m. Classical towing systems are U, V, J, W type, boom device, each requiring a different number of ships.

The type of device is chosen depending on the width of the pollutant film front, its direction and speed and the amount of oil moving.

For reduced widths of the wave of pollution, with amount of oil spilled in small areas, devices with U or V booms will be used. For U and V devices, the distance between the two towing tugs can be at least 80 in.

For greater widths of the pollutant film front, in the case of amounts of oil spilled on large surfaces, pliers device will be used, as it can have a large opening, almost the entire length of the dam used, compared with previous cases when about 1 / 2 the length of the dam held is used.

The type, length of the dam and trawl system will be chosen according to the polluted area, pollution front width and type of intervention ships. There are techniques to use "cascade"trawl systems, that consist of two or more moving formations (U, V or J) so that pollutants will be permanently directed toward the recovery area.

b. The passive mode is to position the dams on a fixed site in steady operation aiming to:

- Limitation of polluted areas – aiming to prevent the spread of the pollutant outside the polluted area by surrounding it with floating dams;

- Protection of areas / objectives - aiming to prevent pollution of vulnerable areas / industrial / water intakes, etc., by closing the area to be protected with floating dams

- Deflecting the pollutant wave in order to redirect the wave on a predetermined trajectory by positioning at an angle of dams, in the way of water movement driven by pollutant

- The pollutant concentration, in order to recover - is achieved by dam location (in the way of movement of the pollutant) on a site calculated such that crude oil pushed by the water current to focus on a certain area.

The dam type, its length, the anchor points are calculated based on the wind and current speed and the opening area / surface area to be protected / limited, as well as forecast hydro-weather conditions.

Calculation methods used to establish the necessary parameters for correct use of dams

The dams use is intended to limit the concentration (thickening of the oil film) and its orientation to established areas.

For this purpose, the anti-oil dams must not permit the passage of oil in any hydro-weather conditions of working.

Usually due to the hydro-weather conditions or misuse, the following phenomena may occur:

* because waves breaking, too high waves, or because of the inappropriate choice of type of dam according to real conditions, oil is trained above dam
* Due to anchoring, wrong positioning or balasting, the dam is not maintained invertical position, or does not create the bank sealing effect, the oil runs under it;
* Also, a too much water current trains the oil under the dam;
* Poor quality or defective coupling allow oil to pass through sections
* Accumulation of too much hydrocarbons in the recovery dam area (during trawling) can cause pollutant training under its skirt.

To eliminate these shortcomings are needed the following:

- **The right choice** of the barrage on types/dimensions, correlated to the zone,the hydro-meteorological conditions, water's deep, way of use (always or not/ active or pasive), functional characteristics.

The tehnical characteristics of the the barrages must be correlated with the functional hydro-meteorological conditions:

	Offshore		For coastal and harbour zone		
Free board (mm)	1300	600	400	300	200
Skirt(mm)	1500	1100	600	500	300
Weight of the ballast chain (kg/m)	36	17	6	5	4
Tensile strenght (kN)	400	200	100	90	50
Maximum height of the wave (m)	6	4	3	1,5	0,5
Stable in $current_{max}$ (Nd)	3	2	2	2	2

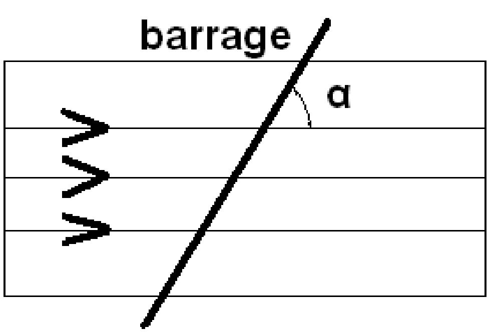
- **Arrangement in curent**

At a greater speed of the water current (when the barrage is towed to fast or when it is used in flowing waters) the oil slips beneaththe barrage. The maximum perpendicular curent on the barrage for which this is efficient has a value of aprox. 0.583Nd or 0.3m/s.

For the case of flowing waters, with a current bigger than 1_5 Nd, the barrages are mounted at an angle so the module of perpendicular resultant of tthe speed on this to be smaller than 0.583 Nd.

The value of the setup angle of the barrage varies with the speed vector module of the current as it is showed in the following tabel:

Critical speed			
Speed curent		sin α	α (°)
knots	m/s		
0.583	0.30	1	90
0.7	0.36	0.833	56
0.9	0.46	0.652	41
1.1	0.57	0.526	32
1.3	0.67	0.448	27
1.5	0.77	0.390	23
1.7	0.88	0.341	20
1.9	0.98	0.306	18
2.1	1.08	0.278	16
2.3	1.18	0.254	15
2.5	1.29	0.233	13
2.7	1.39	0.216	12
2.9	1.49	0.201	12
3.5	1.80	0.167	10
4.5	2.32	0.129	7



The figure show the setup of a barrage at an angle α to the current lines. As the current speed increases with both the value of angle diminishes, and the lenght of the barrage go bigger.

- **The calculation of the forces that acts over a barrage (in current or in towed mode).**

When a barrage is used in a passive or dynamic way is necessary to know the forces that act on it, both for the choice of the constructive type that fits from the towing resistance point of view and for the establishment of the anchoring system or the towing force of the ship that tow the barrage.

On the barrage acts both the current with speed V_c, force F_c, and the wind with a force F_v. The total force F that acts over the barrage results by adding the vectors of the those two frces.

The calculation of the towing force that acts over barrage:

$F=F_c+F_v$, $F_c=kxA_sxV_c^2$, $F_v=kxA_ax(V_v/40)^2$; where:

F= total force (daN);

F_c=the force of the water current over the submerged part of the barrage (kgf);

F_v=The force of the wind over the emersion part of the barrage (kgf);

A_s= the surface submerse (m^2);

v_c= speed of the water current (Nd);

k= proportionality constant = 26

A_a= the surface of the emersion part of the barrage (m^2);

V_v= wind peed (Nd)

In conclusion for a 100m barrage having:

Emersion lenght= 0.6 m;

Submerged lenght= 1 m; that works in the following conditions:

Current speed = 0.4 Nd, on the same direction with the vector

Wind speed = 20 Nd

We obtain a total force of:

$F= 26[100x1x0.4^2 + 100x0.6x(20/40)^2]=806$ daN.

The anchoring force is different, depending on the type of the water bottom on which it is launched:

Anchor Weight (kg)	Mud	Sand	Clay

15	200	250	300
25	350	400	500
35	600	700	700

Choosing criteria for the barrages, depend on factors like:

Hydrocarbon retention capacity :

- the capacity to follow the wave;
- the capacity to stop hydrocarbons to slip under or over the barrage;
- the ability to stay vertical.

Reliability criteria:

- resistance to the tough conditions of maritim environment
  - resistance to tear a part;
  - resistance to UV, temperature,friction and hydrocarbon chemical action .

Use criteria:

- constructive parameters;
- functioning parameters
- transport conditions;
- operational support;
- personal and logistics;
- handling;

Purchase and mentainance costs:

- purchase price;
- costs regarding the washing, drying and storage.

Following the analysis presented and existing systems and adaptive protective barriers for rivers, one of the two solutions presented in the following match in terms of functional requirements of the project.

Inflatable type OIL - BOOM dam stored on the drum

Inflatable dam with its own sort of inflation used in case of contamination with residues of hydrocarbons in order to protect water.

Freeboard is filled with air with an electric exhauster.

Material: Polyurethane Rubber 1080

Buoyancy environment: air

Technical data:

Total height 900 mm;

Freeboard 300 mm;

Draught 600 mm.

Fig. 5.1 Inflatable type OIL - BOOM dam

1.5.2. **Inflatable type SI- Boom dam**

The type SI- Boom dam is a sort of swelling own, used in multiple cases of pollution by hydrocarbon residues in order to protect of water. Dam takes place rapidly in cases of pollution in harbors, dams, water lakes and other protected areas.

Standard length is 20 m dam section and connection of dam section is ASTM Quick type ,system that can connect and other types of dams.

The dam is available in two sizes:

- Freeboard: 190 mm;
- Freeboard: 290 mm.

For both types, skirt is 310 mm.

The dam is equipped with air suction valve located on top of dam and protected roof, allowing air to enter in the buoyancy room where the dam is carried out and folded.

When the dam is stretched out, room air will be filled with air to

when they extend and maintain the correct size of the room in accordance with

current speed.

When the dam is recovered, the air is discharged through the open valves and the dam is collected and placed in polypropylene bags, each containing 20 m of the dam.

A bag can be easily carried by two people.

Mechanical properties and dimensions of the SI- Boom dam:

Freeboard (mm)	190	290
Draught (mm)	310	310
Height (mm)	500	600
Standard length (m)	20	20
Connectors	ASTM Quick	ASTM Quick
Skirt material	Oil resistant PVC	Oil resistant PVC
Color	Orange	Orange
Weight (kg / m)	1.75	2.05
Buoyancy strength (kg / m)	18:1	34:1
Ballast material	6 mm galvanized chain	6 mm galvanized chain
Ballast weight (kg / m)	0.7	0.7
Total resistance (N)	22,500	22,500
Tensile strength of fabric (N/50mm)	2500	2500
Storage volume (m^3/20m)	0.2	0.25
Total weight for a section of 20 m (kg)	35	41

Ballast is 6 mm galvanized chain link mounted to the bottom of the skirt.

Fig 5.2 Inflatable type SI- Boom dam

5.3 Infested water collection system

Whichever solution is adopted, either by ship-mounted installation, or one of the following terrestrial fixed or installed on a ground vehicle, polluted water collection system, must include parts presented in **Fig. 5.3**

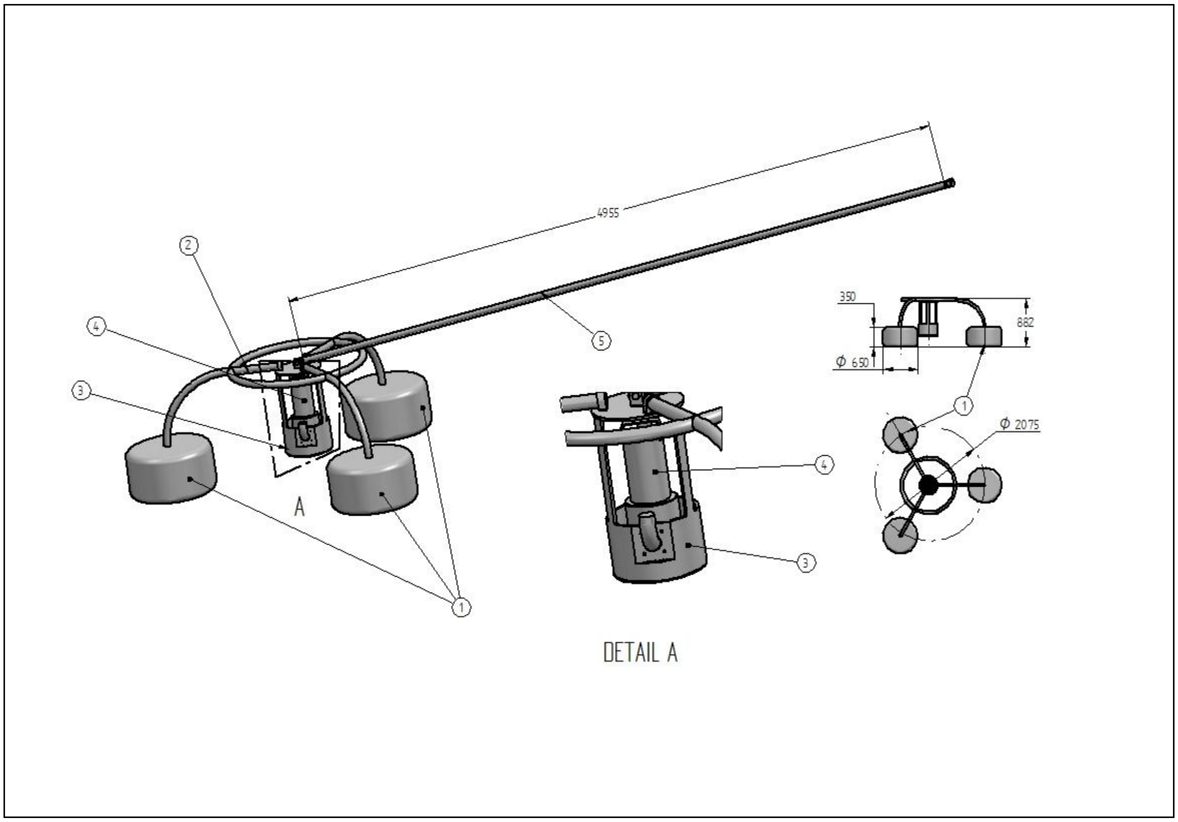


Fig 5.3 Infested water collection system

1. Float chambers
2. Welded frame
3. Pump support
4.Pump
5. Guide rod

Pump support item poz. 3 is provided in bottom with a filter to prevent any solids entering the pump suction**.**

The following table shows a range of submersible pumps manufactured by ZEHNDER. For our application we chose pump ZFS D Ex 70.4.

Overall dimensions of the pump ZFS D Ex 70.4 are shown in fig.5.4

SUBMERSIBILE WASTE WATER PUMPS- CAST IRON

Series ZPG 50 / ZPG 70 (also as Ex-model)

FEATURES:

- submersible waste water pump in mono block system made of cast iron
- for portable or fixed applications
- motor winding protected with a thermal overload (except ZPG 50 D)
- sealed with tandem mechanical seals (ZPG 70) or mechanical seal and additional shaft seal (ZPG 50)
- pump housing, motor housing and impeller made of cast iron, shaft made of stainless steel
- driven by a three-phase or single phase motor
- ZPG 50 - impeller with **45 mm clearance**
- ZPG 70 - impeller with **20 mm clearance**
- pressurized discharge DN 50
- ZPG 50 W (version A) mounted with a float-switch
- ZPG 50.X D and ZPG 70.X with optional float-switch (accessory)

APPLICATIONS:

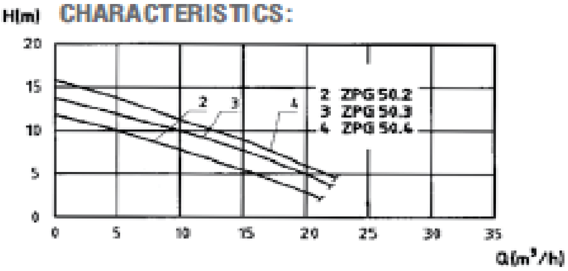
- removal of dirty water without faeces but with solid impurities
- removal of rain- and surface water
- as portable pump for emergency dewatering and emptying of canals

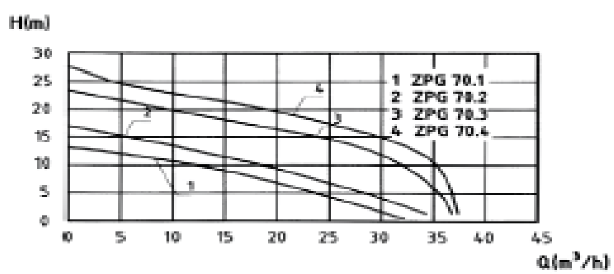
TECHNICAL DATA:

Type	Item-No.	P_1 [W]	P_2 [W]	U [V]	I_N [A]	n [min^{-1}]	Qmax [m^3/h]	Hmax [m]	Weight [kg]
ZPG 50.2 W	26522	1,1	0,8	230	5,2	2800	23	12,0	23
ZPG 50.2 W A	26522A	1,1	0,8	230	5,2	2800	23	12,0	23
ZPG 50.3 W	26532	1,4	1,0	230	6,2	2800	26	14,0	23
ZPG 50.3 W A	26532A	1,4	1,0	230	6,2	2800	26	14,0	23
ZPG 50.4 W	26542	1,6	1,2	230	7,4	2800	29	16,0	23
ZPG 50.4 W A	26542A	1,6	1,2	230	7,4	2800	29	16,0	23
ZPG 50.2 D	26523	1,1	0,9	400	2,3	2800	23	12,0	23
ZPG 50.3 D	26533	1,4	1,1	400	2,6	2800	26	14,0	23
ZPG 50.4 D	26543	1,6	1,3	400	2,8	2800	29	16,0	23
ZPG 70.1 W	26710	2,2	1,6	230	10,5	2800	32	14	38
ZPG 70.1 D	26711	2,1	1,7	400	3,7	2800	32	14	38
ZPG 70.2 D	26721	2,1	1,7	400	3,7	2800	34	18	40
ZPG 70.3 D	26731	3,9	3,2	400	6,5	2800	36	23	44
ZPG 70.4 D	26741	3,9	3,2	400	6,5	2800	36	28	46
ZPG 70.1 W Ex	26712	2,2	1,6	230	10,5	2800	32	14	38
ZPG 70.1 D Ex	26713	2,1	1,7	400	3,7	2800	32	14	38
ZPG 70.2 D Ex	26723	2,1	1,7	400	3,7	2800	34	18	40
ZPG 70.3 D Ex	26732	3,9	3,2	400	6,5	2800	36	23	44
ZPG 70.4 D Ex	26742	3,9	3,2	400	6,5	2800	36	28	46

operation temperature: 40°C

CHARACTERISTICS:





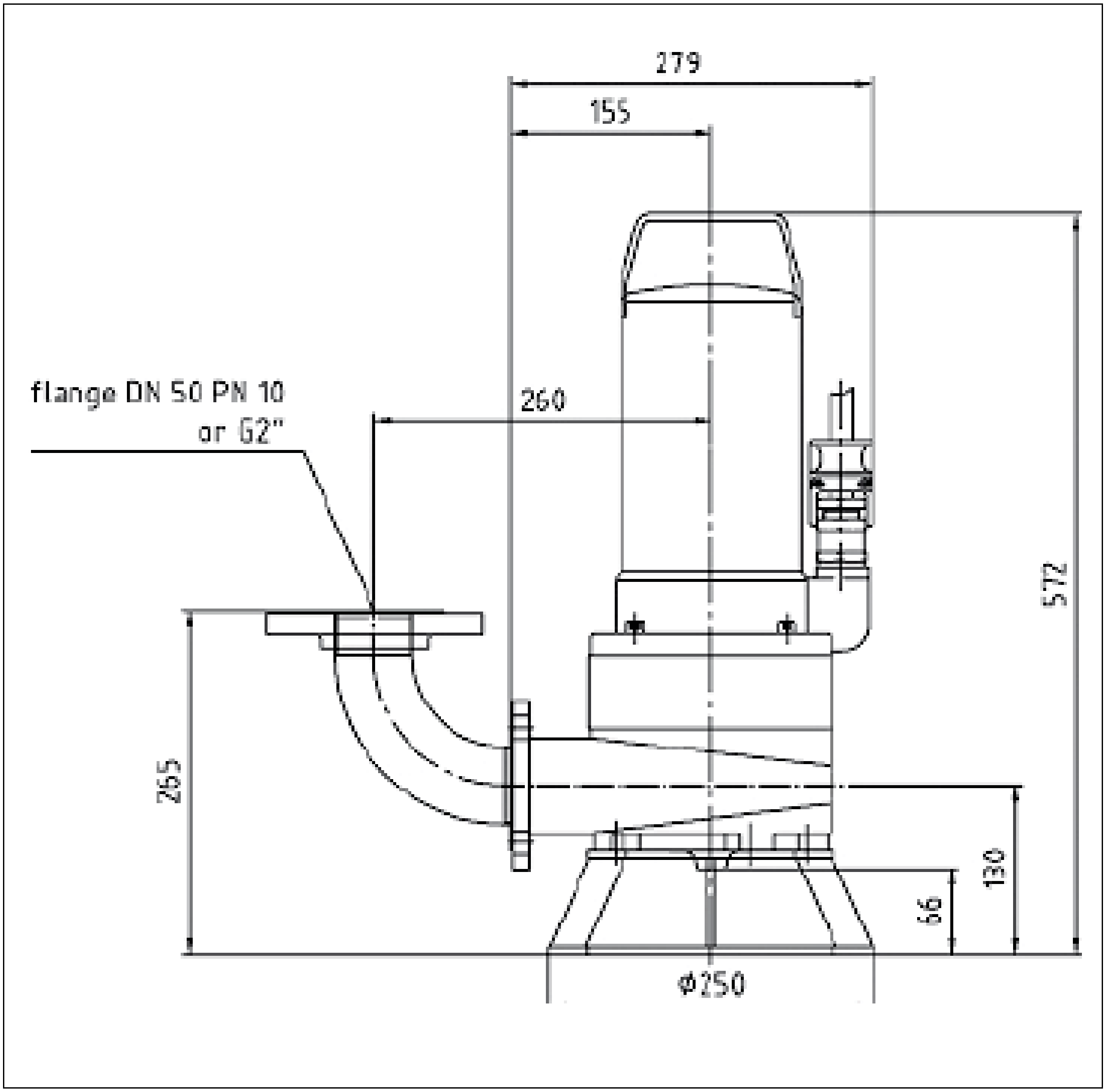
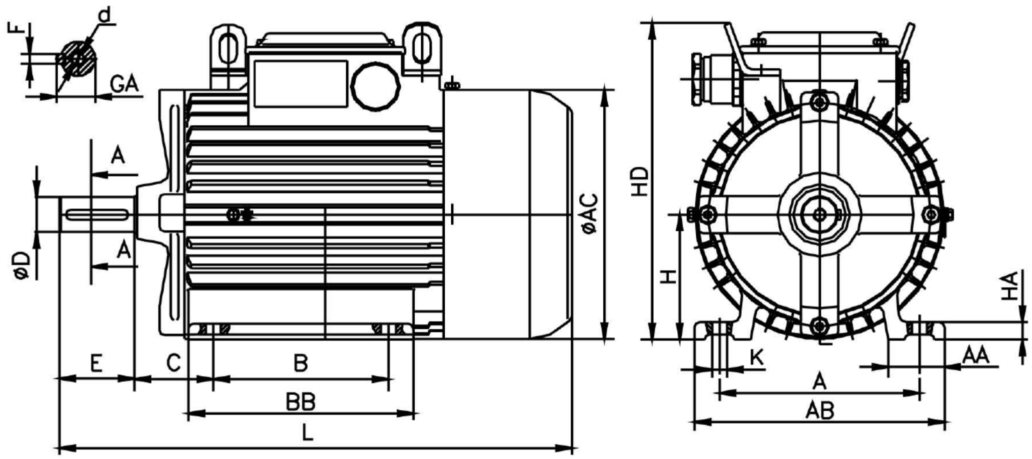


Fig. 5.4 Overall dimensions of pump ZFS D Ex 70.

5.4 The technological and functionality aspects of centrifugal separation plant

Computation of the driving engines of the installation was presented in study No.4. Theoretical calculation formulas are generally indicative and therefore in practice using similar methods.For main drive

For the main engine driving power required is 45 KW and for cyclo gerarbox drive motor the power required is18 kW.



Gabarit	A	B	C	H	K	D		E	F h9	GA	d	HD	L	BB	AB	AA	HA	AC
						Nom.	Tol.											
63	100	80	40	63	7	11	j6	23	4	12.5	M4	162	258	104	131	31	9	125
71	112	90	45	71	7	14	j6	30	5	16	M5	182	295	125	141	37	9	140
80	125	100	50	80	10	19	j6	40	6	21.5	M6	216	287	125	155	35	9	158
90S	140	100	56	90	10	24	j6	50	8	27	M8	238	339	150	170	37	9	177
90L	140	125	56	90	10	24	j6	50	8	27	M8	238	339	150	170	37	9	177
100LW	160	140	63	100	12	28	j6	60	8	31	M10	257	387	176	200	47	10	199
100LX	160	140	63	100	12	28	j6	60	8	31	M10	257	387	176	200	47	10	199
112M	190	140	70	112	12	28	j6	60	8	31	M10	284	406	176	224	55	12	221
132S	216	140	89	132	12	38	k6	80	10	41	M12	333	496	220	264	68	14	263
132M	216	178	89	132	12	38	k6	80	10	41	M12	333	496	220	264	68	14	263

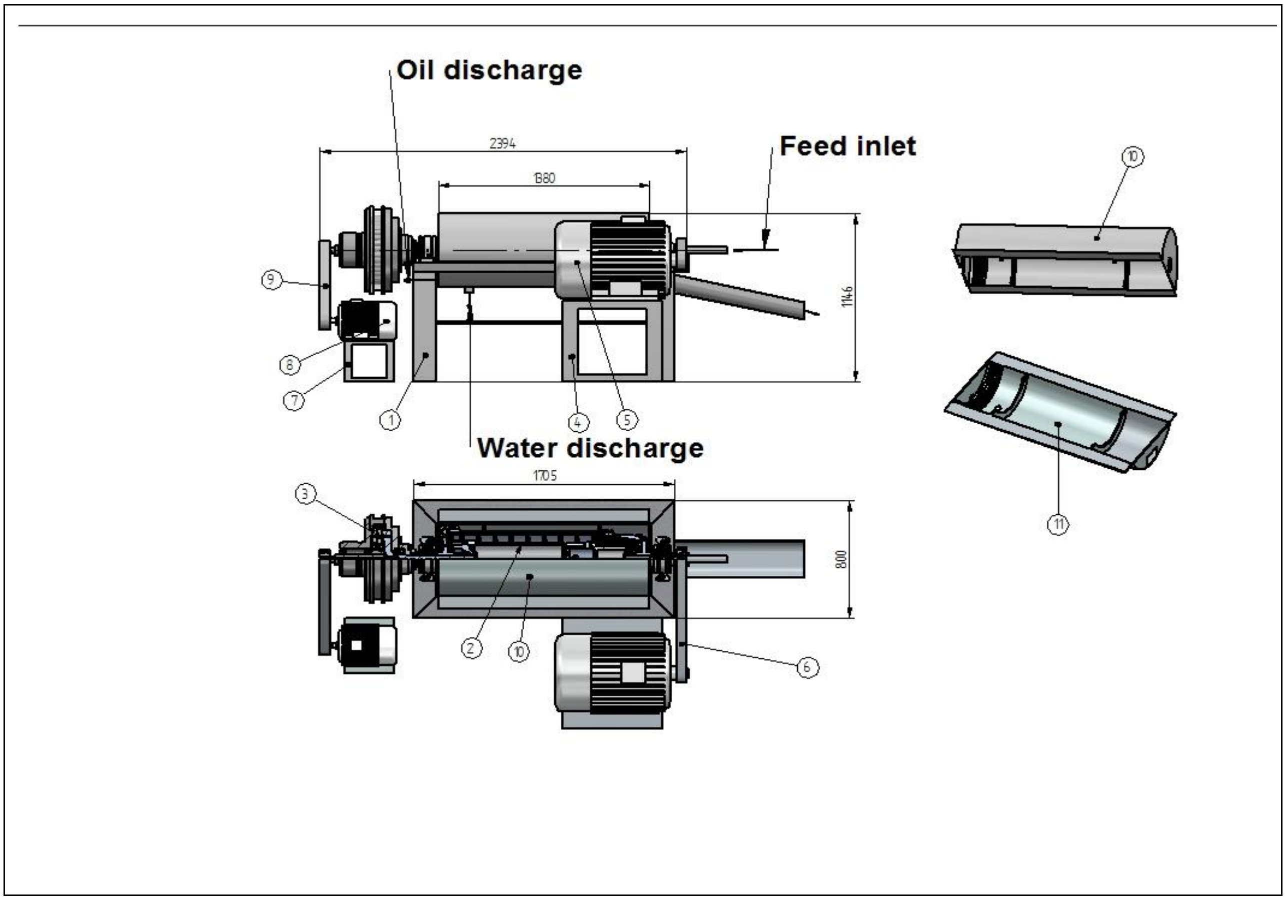


Fig. 5.5 Overall design of centrifugal separator plant

1. Centrifugal separator frame;
2. Centrifugal separator;

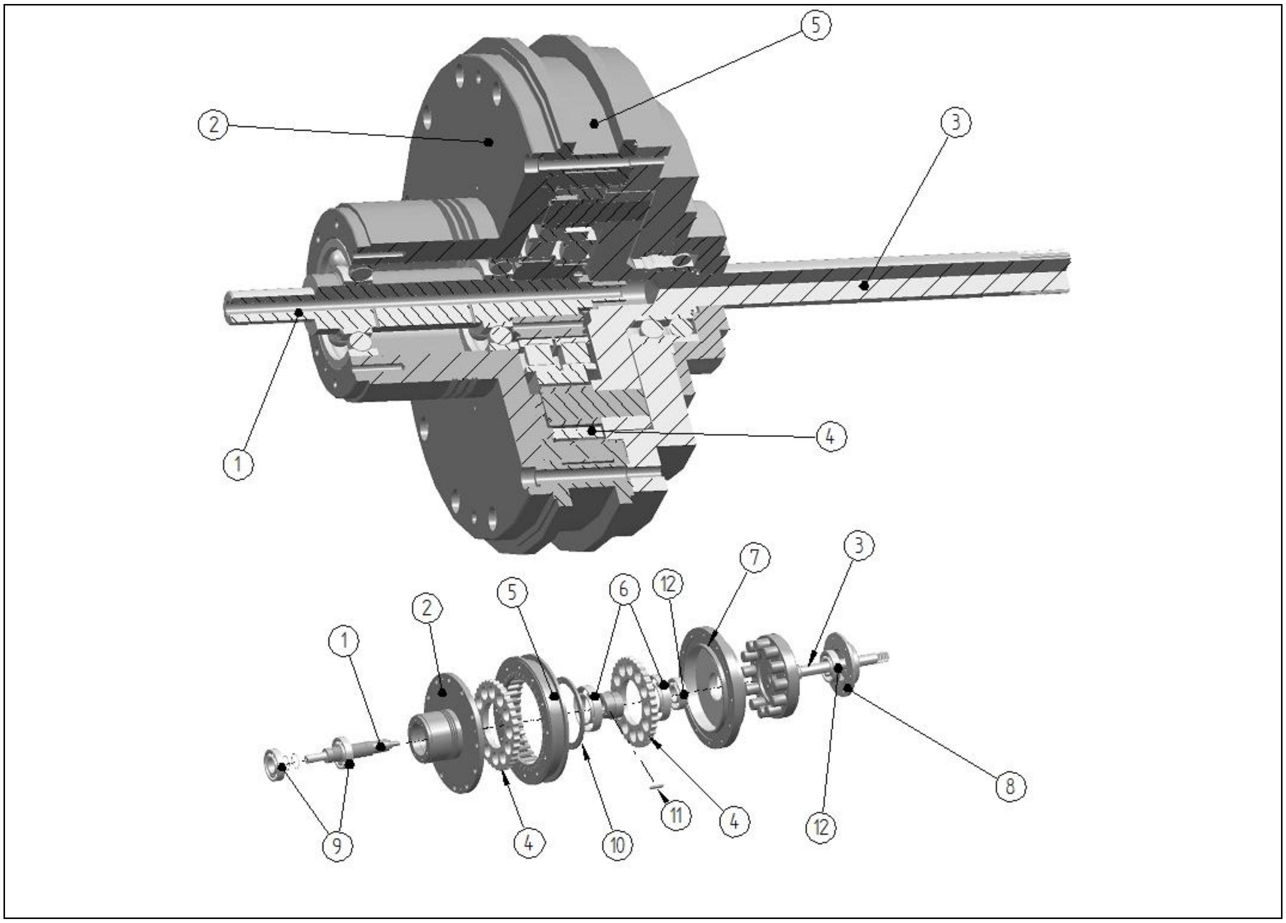


Fig. 5.6 Cycloidal gearbox

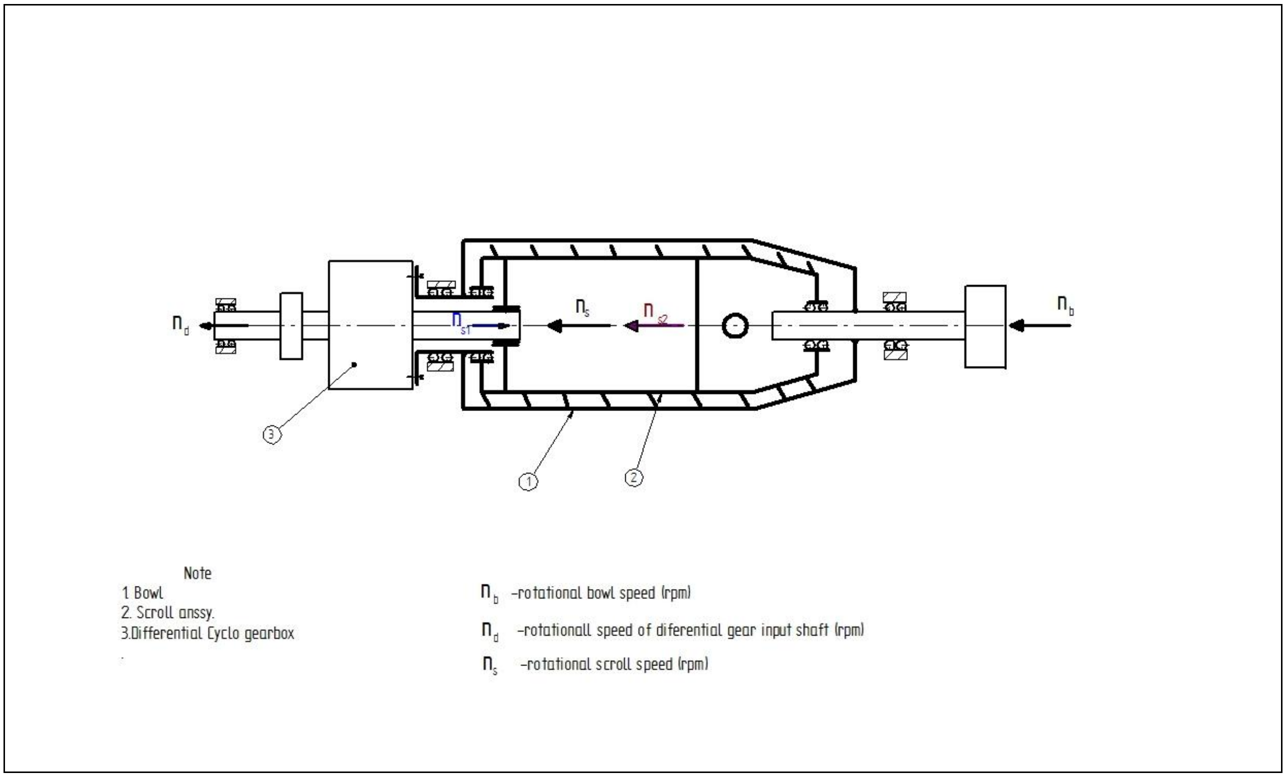


Fig 5.7 The kinematic scheme of centrifugal separation plant

5.5 Instrumentation and Control

The first production decanters were virtually devoid of instrumentation and control, apart from the main motor starter. Today, instrumentation and controls are many , and can be quite sophisticated,. The present tendency is for full automation, to minimise the need for human intervention, and reduce labour costs. Improved safety standards have encouraged the development of some useful, and reliable, instruments. The development of small, affordable controllers themselves has enabled the introduction of some much needed process instruments. Hitherto an expensive process instrument could not be justified to be used merely as a monitor.

When a decanter is automated, automation of a lot of the associated equipment is also necessary, together with interlocking. For instance, it would be inadequate to have a decanter operating automatically unattended if failure of the cake off-take system could occur without communication of the fact to the decanter control system.

Figure 5.8 depicts an instrument and flow diagram for a decanter plant with alternative cake discharge flows for thickening and dewatering. It is not possible to cover every eventuality with one diagram, but this one covers the majority of usual situations. The instrumentation shown is not necessarily always used, but is that which the plant engineer would consider useful, were it possible. The equipment that could be controlled automatically, or is controlled in standard plants, is marked. Each of these possible instruments will be discussed in turn, after outlining the various modules of a decanter plant.

- Control Input
- Electrical Amps/Watts
- Level
- Count
- Pressure
- How Rate
- Speed
- Time
- Torque
- Solids Concentration
- Temperature
- Decanter Plant Modules

A fully equipped decanter centrifuge plant will normally have several distinct modules within it:

the process slurry feed system;

the decanter itself;

the centrate off-take system; and

the cake discharge system.

The feed will be supplied from the main plant. This could simply be a tee into a pipeline of the plant, or more usually from a storage tank. A variable speed pump, usually a progressive cavity type, feeds the process slurry to the centrifuge. The rate is fixed manually or by a plant controller.

The decanter system itself hardly needs further description. The main motor and back-drive motors are the main control inputs. Larger decanters may have a separate oil lubrication system for the main bearings, in which oil flows, temperatures and pressures are monitored.

The centrate off-take system is generally a large pipe to drain, or to a receiver vessel. Occasionally the decanter will be fitted with a centripetal or skimmer pump, when a pressurised discharge will occur, which may have to be released below the liquid product surface in the receiver, to prevent or reduce foaming. In three-phase decanters a second light phase discharge will be present, the flow of which will also need measuring.

Dewatered cake is often discharged onto a belt conveyor, straight into a hopper, or perhaps into a screw conveyor or elevator. Where decanters employ negative pond operation, ponds deeper than the cake discharge level, unwanted liquid discharge from the cake outlet can occur during start-up.' This can produce an unpleasant mess on belts, causing them to slip, and will contaminate the product. This is sometimes prevented using notched weir plates, or special start-up and shut down procedures. Alternatively, devices are fitted under the cake discharge to feed the wet cake back to the feed vessel. These devices could be, alternatively, a flap diverter, or a hopper that is automatically moved under the discharge at start-up. The unwanted liquor discharge is then pumped back to the feed tank. A further alternative is to angle the belt conveyor, such that liquid flows back down the belt into a hopper, while solids convey upwards on the belt. With all these devices some flush may be required after the wash-out has ceased.

Thickened cake discharge can simply be into a hopper which is emptied by a pump actuated by level probes in the hopper. However, modern technology often requires the discharge to be monitored for solids content, if not rate. For this a small stirred buffer tank is used. A sample from this tank is pumped and recycled continuously to provide a continuous sample. The stirred buffer tank is sized to smooth out major fluctuations which can occur in the decanter discharge, due to hold-up in the casing.

Instrumentation

This section is separated into the various categories of instruments, such as flow meters, solids concentration meters and timers. Lastly, controllers will be covered.

Flow meters

Flow meters for aqueous slurries are reliable, accurate and seldom require adjustment after initial calibration. Moreover they are amenable for connection to PLCs, computers and controllers. The most common models used on decanter plants are eddy current and ultrasonic type. Flow meters are used on the feed line after the feed pump and similarly on the polymer line.

Flow measurement is employed on the oil lubrication lines, but is usually of the rotameter, or variable orifice type. This means that they are used for indication only, and are not readily coupled into the control system, unless simply as alarm features.

Ideally, a flow meter should be fitted on the thickened cake recycle line. This is because the solids monitor works on the principle that the cake solids concentration is a function of viscosity, which in turn is monitored as a pressure drop when flowing. Thus the flow rate also affects the pressure drop, and therefore must be kept constant. However, often it is found that plant users rely on the constant rate from a metering pump, making periodic adjustments to flow or calibration should the pump wear.

The total flow of thickened cake is usually obtained by calculation, but a check can be made by measuring the time intervals between discharge of the sump tank. This would be how the oil flow is measured from a three-phase decanter.

If dilution water is used, this is generally measured with a rotameter variable orifice meter. However if this flow has to be integrated into a control system then an electronic method, as used for the feed, will be necessary.

Solids concentration meters

These monitors tend to be the most expensive instruments, but enable the most sophisticated type of process control. Without them "live" measurement of, for example, solids recovery, polymer dosage, cake and centrate rates, and product quality would not be possible. Some laboratory analyses take a few hours to perform, by which time the plant could be way off the control desired.

A few companies offer devices that can continuously measure solids content of feed flows. Various principles have been used, including the coriolis effect and the use of a radioactive source. The method using a radioactive source has proved reliable, but there is resistance to using it where a' watercourse is involved, and moreover there are stringent regulations with regard to the disposal of the instrument once it is at the end of its useful life. Nevertheless the suppliers naturally offer a comprehensive service. Light reflection or transmission is another method that is in use.

Centrate solids concentration measurement is an important parameter for decanter control. Several such instruments are available to measure in this range. However, one problem presented by centrate from a decanter, on many applications, is the copious production of bubbles or foam in the flow. These bubbles are read, by many instruments, as solids, thus preventing the use of such devices. De-aeration of a sample flow of the centrate has met with a modicum of success. Some decanter manufacturers developing their own instrument have obtained more success.

Continuous measurement of solids, or moisture content, of dewatered cake, as far as is known, has not been practised on decanters yet. However, infrared devices, which can measure moisture content of products on conveyor belts, when positioned about 30 cm above the belt, have been reported.

Level probes

There is no great need to measure levels in the plant, but merely to have an indication of whether a tank or hopper is empty, full, or in between. This is achieved by conductivity, or sonic, probes. They are fitted to the two polymer tanks, to initiate a new batch make-up, and to actuate transfer before the polymer supply tank empties. Probes could be employed in the polymer powder hopper to guard against running out during operation. Smaller plants will not use powder probes, and rely on a system using several days' supply.

Speed probes

It is particularly necessary to measure the speed of rotation of the decanter bowl and the gearbox pinion shaft. Occasionally a tachometer will be built into the braking device. More generally, bowl and pinion speeds are measured by proximity probes, acting on a protuberance or casteilation, on a spigot/hub or shaft.

The speeds of the feed and polymer pump, and also the cake sample pump, are useful though not absolutely necessary to measure, as comparing this speed with a calibration speed will indicate the onset of wear.

Measuring the speed of the polymer screw feeder has already been mentioned.

Another useful speed monitor would be on the solids conveyor driven shaft. All that is needed here is an indication that the shaft has stopped, for instance if the belt should break. In a non-attended plant it is essential to know if the off-take system ceases to function, so that the feed may be arrested.

It is worth noting that the majority of downtime of a decanter plant is caused by failures in ancillary equipment, rather than the decanter itself.

Temperature probes

The temperature of the lubricating oil from the bearings is usually measured with thermocouples. The temperature of the feed is only measured if this is an operating parameter. The temperature of motor windings are usually monitored by thermistors, connected to a safety cut-out system in the motor control gear. Obtaining a direct reading of motor winding temperature would be unusual.

Torque measurement

Conveyor torque today is an essential part of decanter control. However, direct reading of conveyor torque is very difficult to achieve. Even direct reading of pinion torque is difficult, but could be done using strain gauges on the pinion shaft. However, the most usual method is to use a calibration of the braking device. The control device for the brake will give a read-out, on request, of the braking torque.

Timers

Timers are integral parts of some of the control systems. They are used in the starter of the main motor, to switch from star to delta operation. They are used in control systems, for the sequential start-up and shut-down of ancillary equipment. Timers are used for the ageing of the polymer, and the on-time of

the feeder. A timer would be used to measure the fill time of the cake sump, to check cake rate.

However, although run-time meters can be fitted to most motors, this is usually, if at all, only on the main motor.

Counters

Counters are used to count batches of polymer made up, to keep an overall check on usage. Cumulative flow is often found in electronic flow meters, to keep account of total flows through the plant.

Electrical meters

The current to the main motor is often monitored to prevent overloading. It also gives an indication of the power being consumed, although a better device for this is the wattmeter.

Bearing monitors

Interest is now being placed in instruments that monitor the health of bearings in operation. Premature failure can be predicted before expensive damage occurs. These instruments are not yet in wide use.

Controlled Equipment

The control strategy for a decanter plant often will hinge on experience, the user's requirements, what is available and the extent of control required. One of the main decisions to make is regarding the flocculant control. The option for flocculant control is whether to have a feed-forward control, requiring a feed solids meter, or whether to have feedback control using a centrate solids monitor. With feed-forward control, the flocculant rate is modulated according to the level of solids in the feed. The ratio of flocculant to feed solids may have to be trimmed occasionally should .the quality of the feed vary. With feedback control the control performance is independent of feed quality. Nevertheless some centrate monitors can be badly affected by aeration and foam which can occur with some polymers and feeds. The extent of the sophistication of the control will depend upon how much of the plant is required to be incorporated into the decanter system. The good functioning of feed tank levels, off-take pumps and conveyors all may need to be brought into the strategy with appropriate interlock controls.

To devise a control strategy for a decanter plant, it is necessary to know what devices are available to the controller. These maybe on/off devices, or devices which can be varied in output by the controller.

On/off devices

These will include the stirrers in the polymer system and thickened cake sump. Also included will be complete module systems, such as the polymer system, the oil lubrication system, and perhaps the cake off-take system. The decanter main motor is also a controlled on/off device, although a variable speed main motor can be employed.

The pumps actuated by the level probes on the polymer system, and the sump discharge, are also on/off devices, as are the belt conveyor, the cake diverter, and the polymer screw feeder.

In a completely manual plant, even the feed and polymer pumps could be on/off, and merely controlled on or off by safety interlocks.

Variable output devices

These are mainly the feed and polymer pumps, and the decanter brake torque or speed. However, in special cases, the actual bowl speed could be a part of a control strategy. The pond depth itself, using the inflatable dam, could be used in a thickening control strategy.

The polymer feeder could be used in a control system, if wide ranges of feed concentration were to be anticipated. As far as is known, this has not yet been' used.

Controllers

Modern electronic technology has provided industry with a wide choice of small, user-friendly, cost-effective controllers, with proportional integral and derivative (PID) control action.

The main motor controller is a separate controller, and depends upon the type of installation and motor. The motor could be AC, DC or inverter type. Rarely, it could be a hydraulic motor. The starter could be DOL (direct-on¬line), particularly if a fluid coupling is fitted, it could be a soft-start inverter system, or a DC system. With an inverter system the back-drive, also an inverter type, could be connected through the DC bus to allow power regeneration. The starter itself could be actuated by a separate master system. Undoubtedly there will be interlocks with the starter, to cause it to de-energise with certain scenarios.

All the controllers are important, but the most important controller for the process is the one controlling the gearbox pinion shaft brake. This PLC(programmable logic computer) will be required to control the brake, either to give a set conveyor differential, or a set output torque. Whilst this duty, as specified, seems simple, the overall duty expected makes it, internally, quite complex. In certain circumstances it is required to control speeds close to zero and even to reverse speed. It is expected to be suitable for the complete range of a manufacturer's decanters, and yet expected to control each within safe limits. Moreover it needs to be appreciated that reducing output torque allows a lower differential, which increases torque! Thus to allow a higher conveyor torque, the controller effectively has to reduce its output torque. Nevertheless, excellent controls have been established on several thousands of installations.

A good brake controller will be required to indicate:

- Bowl speed;
- Conveyor differential speed;
- Brake or conveyor torque;
- Torque high/low alarm;
- Differential high/low alarm;
- Status (start-up or running);
- Mode of control (torque/differential);
- Set point.

Access is needed to the operating parameters, with an encrypted code to prevent unauthorised tampering. One such controller is shown in Figure 8.2.

Only after using such an instrument can the extent of the needs for such a device be appreciated.

The operating parameters may include:

- Entry code;
- Modes permitted;
- Upper and lower alarm limits;
- Set points;
- Set point limits;
- PID settings;
- Secondary PID settings for two-stage control;
- Sense of alarms (normally on or off);
- Gearbox ratio; *
- Pulses per revolution for probes;
- Pulley ratios for speed recalculations;
- Control ramp rate;
- Calibration of external signals;
- Parameters for transmission of data;
- Parameters for computer communication;
- Brake torque/current calibration reference.

This is a very brief synopsis of what could be 60 or more separate parameters.

Integrated Controller

With separate controllers already provided to control separate functions of the plant, it is an obvious next step to integrate them into one master controller, or to supply a master controller to supervise the individual controllers. This is being demanded increasingly. Some large plants demand a central remote control room, with mimic diagrams, all controlled by one central, large industrial computer.

Some decanter manufacturers already have their own integrated controller, all with varying degrees of sophistication. Some of the duties of an integrated controller are described below.

All the signals available, need to be continuously fed to the controller and converted to digital figures. It should be possible to display any of these figures on request.

The figures then need to be processed, according to the relationships in Study no.4 to provide figures of:

Solids recovery;

Torque/volume;

Feed rate/g-volume;

Centrate rate;

Cake rate;

Cake rate/differential;

Power usage on the decanter and the total.

These should all be displayable.

A cost display should be possible, once application itemised cost data are inputted. The data required for an effluent would include the cost of power at various times of the day, cost of effluent disposal, polymer cost, and cake disposal cost. Other costs that may be included would be, for example, amortisation of capital. The processor would then work out the plant running costs for display, or periodic print out.

The controller processor would have in-built control algorithms for the plant manager to select. Control could be to minimise overall cost, maximis

dryness, minimise revenue costs, or maximise throughput. It could also be on the basis of keeping the feed tank down to a certain level. Priorities would need to be set for the various performance factors, such as solids recovery, dryness, cost and throughput. Maximum and minimum levels for each would need to be set.

The controller would be set on a continuous loop to conduct the calculations, perform*control adjustments, display and if necessary print results, and act as an annunciator for alarms and maintenance schedules.

The control method could be a simple "hill climbing" technique where small adjustments of one variable at a time are made, and performance checked. The adjustment continues so long as performance improves and a step back is made once a deterioration is detected. The next variable is then adjusted in the same way. Adjustment steps could then be reduced once all variables have been used. The process is then repeated.

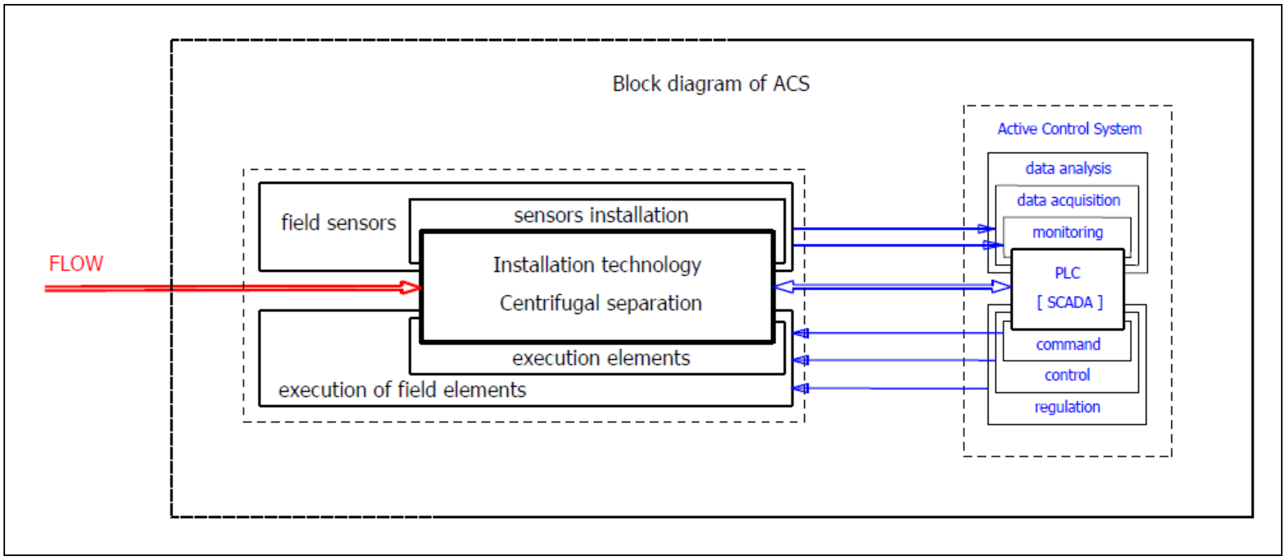


Fig. 5.8 Block diagram of command and control system.

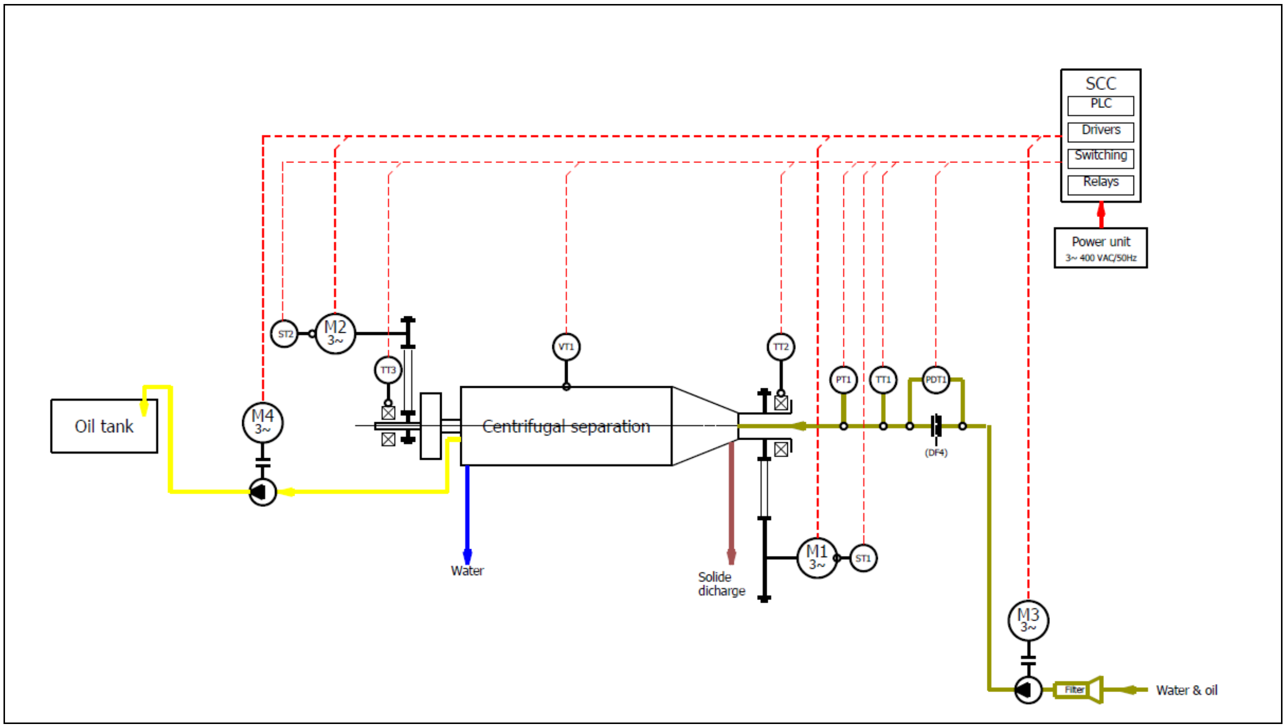


Fig. 5.9 Instrumentation technological scheme of the installati

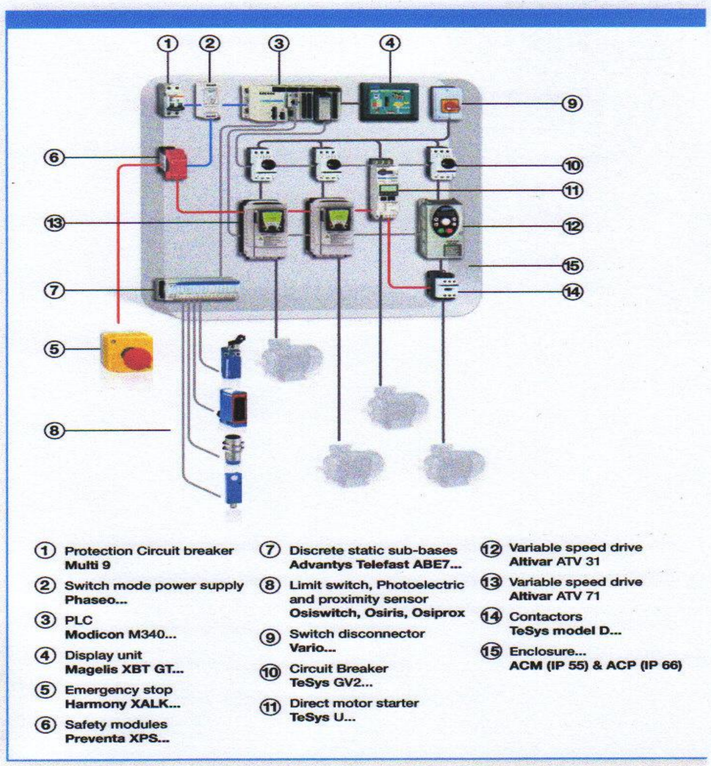


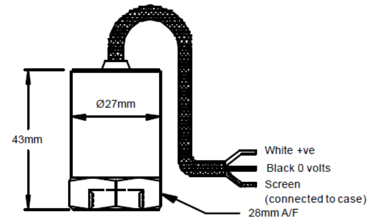
Fig. 5.10 Establishment of automation and control system structure

MTN/1185C Series

4-20 mA Velocity Transducer for PLC interface

Applications

- Air handling units
- Building services
- Fans



Technical Specification

Output Current	4-20mA DC proportional to RMS velocity (mm/s)
Velocity Range	See table below
Frequency Response	2 Hz to 1 kHz ±10 %
Dynamic Range	50 g peak
Mounted Resonance	5 kHz min
Isolation	Base isolated
Operating Temp Range	-25 to 90 °C
Temperature Sensitivity	0.08 %/°C
Transverse Sensitivity	Less than 5%
Supply Voltage	12-32 Volts DC (for 4-20mA)
Standard Cable	5 metres armoured PTFE
Maximum Cable Length	1000 metres
Case Material	Stainless steel
Weight	150 gms (nominal)
Sealing	IP67
Mounting Torque	8 Nm
Options	Ranges, connector, side exit cable, filters, mounting threads, other cable lengths, intrinsically safe, high temperature.

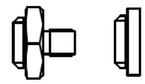
ORDER CODE PART No	MOUNTING	xx =VELOCITY RANGE AVAILABLE (+/- 10%)
MTN/1185C-xx MTN/1185CQ-xx	¼ UNF FEMALE QUICK FIT FEMALE	0-10 mm/sec RMS 0-20 mm/sec RMS 0-25 mm/sec RMS 0-50 mm/sec RMS 0-100 mm/sec RMS
FOR OTHER MOUNTINGS SEE OVER PAGE.		

Mounting Adapters and Studs

Studs and Grub Screws

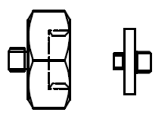
Male Studs		
Product Code	From	To
MS036	1/4" - 28 UNF	M6
MS039	1/4" - 28 UNF	10 - 32 UNF
MS067	1/4" - 28 UNF	M8
MS068	1/4" - 28 UNF	1/4" - 28 UNF
MS124	1/4" - 28 UNF	M10
MS132	1/4" - 28 UNF	M12

Quick Fit Adapters



Quick Fit (Q/F)		
Product Code	From	To
MS001	Q/F Male	Glue Base
MS002	Q/F Male	M8 Male
MS003	Q/F Male	M10 Male
MS004	Q/F Male	1/4" - 28 UNF Male
MS006	Q/F Male	M6 Male

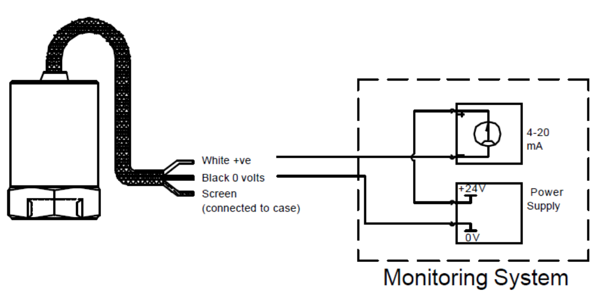
Other Adapters

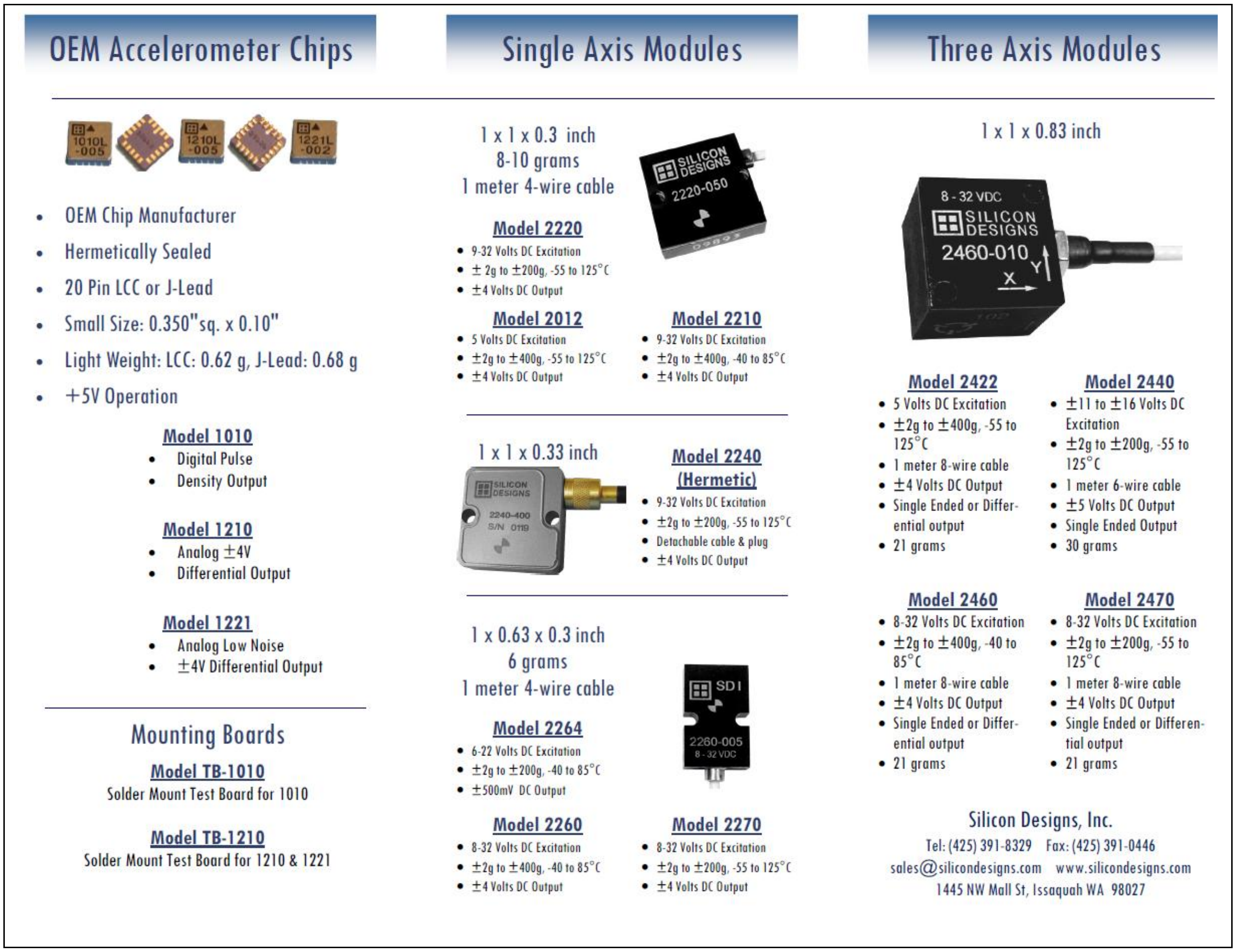


Mounting Adapters		
Product Code	From	To
MS005	Q/F Male	1/4" - 28 UNF Female
MS007	Q/F Male	10 - 32 UNF Female
MS008	Q/F Male	M8 Female
MS011	1/4" - 28 UNF Male	Q/F Female
MS013	1/4" - 28 UNF Male	Glue Base
MS033	1/4" - 28 UNF Male	Q/F Female
MS038	Q/F Male	M8 Conical Male
MS061	1/4" - 28 UNF Male	10 - 32 UNF Male
MS079	1/4" - 28 UNF Male	Q/F Female
MS106	Q/F Male	M10 Female

Isolation		
Product Code	From	To
MS034	1/4" - 28 UNF Male	1/4" - 28 UNF Female
MS093	Q/F Male	M8 Male

System Connection





5.6 Conclusions

Mechanical recovery method and the pollutant concentration is recommended because it is the "cleanest", the pollutant is recovered completely without water or air transfer as in other cases (dispersion, combustion).

The method requires some hydro-meteorological conditions limit but can develop at any time and any type of pollution petrol. The method based products is expensive but once completed it is safe, because it does not require re-runs are complete and the recovery of pollutants, can become effective and economically.

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