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1. ADDITIVE INJECTION

1.1 GENERAL

Additives are added for several reasons such as safety, quality improvement, tax laws and, most commonly, product differentiation.

1.2 DOSING LOCATION

There are many factors, which influence the selection of dosing location, including the type of facilities available, whether these are shared or owned by third parties, and the extent of product exchange agreements.

1.2.1 Refinery dosing

Refinery dosing - or dosing as product is received into storage - is only possible if the entire product is sold with the same additive. Refinery dosing has the following advantages:

1. Maximum time to detect and correct for under/overdosing;
2. Purchase of additive in bulk by ISO tank or road tanker;
3. Improved quality control by incorporating back-up systems and downstream checking before the product leaves the refinery/depot;
4. Minimum number of injection points, thus reducing costs;
5. Greater product homogeneity.

However, there is an inevitable long supply chain, which leads to the following disadvantages:

1. Potential slow additive build-up through the distribution system before the correct dose is delivered to the customer;
2. Inflexibility during changes of additive, leading to mixtures of varying composition being present in the system for long periods;
3. Less freedom for future product differentiation.

1.2.2 Depot tank dosing

This avoids most of the disadvantages of refinery dosing, while retaining the advantages of simplicity and relatively low cost. However, it is not as flexible as gantry dosing (below), and does not appreciably facilitate future differentiation.

1.2.3 Loading gantry dosing

Where product is required both with and without additive, or where third parties require different additives the additive will normally be injected at the gantry, just upstream of the product flow meter. This has the following advantages:

4. Flexibility;
5. Facilitates future differentiation initiatives.

The disadvantages are:

6. High initial investment costs;
7. Increased quality assurance requirement (there is a risk that each road bulk vehicle can be incorrectly dosed; there is often no time to discover an incorrect dosing before the product reaches the customer).

To make gantry dosing acceptable, the following measures are generally taken:
8. A secure additive selector system is used (automatic selection is preferred to manual or key selectors);
9. The injector control system incorporates a feedback signal, which confirms that dosing is taking place. If dosing does not take place within the specified limits, loading should be interrupted;
10. Additive volume totaliser meters, in order to enable a periodic check on the correct injection ratio (at least daily, but preferably at the end of each shift) are provided.

1.2.4 On-board dosing

Additives may be added manually into the compartments. Manual dosing of additive is generally not acceptable because of the dangers of poor quality control, poor mixing and Health and Safety considerations.

Delivery vehicle on-board injectors are also available. These are not employed because quality control is difficult and product homogeneity is hard to guarantee. They are only used as a temporary measure or where justified by local conditions.

1.3 GENERAL DESIGN GUIDELINES

1.3.1 Turndown ratio

Continuous developments in the formulation of additives very often require adaptation of the dosage rate. A high turndown ratio is therefore an important design criterion for on-line injection facilities into bulk products. This flexibility has the added advantage of allowing a switch from one supplier of additives to another, should this be desirable on additive performance and/or economic grounds.

1.3.2 Additive type

A major influence affecting the design rules for injection facilities are the characteristics of the additives themselves. The main characteristics, which have to be considered, are:

- Toxicity;
- Chemical and thermal stability (including shelf life of the additive);
- Viscosity;
- Compatibility with additive system materials (e.g. elastomers).

Toxic additives require gas-tight designs; pump seals and special precautions for their transfer. The pump seals should be compatible with the type of additives to be used. Thermal stability properties will dictate the requirements for temperature alarming, safety relief valves and the use of special injection systems such as eductor systems. Viscous material may pose particular handling problems when the additive is delivered from the Manufacturer.

The different characteristics of each additive may require specific design and operating guidelines.

1.3.3 Injection methods

The injection methods can be subdivided into:

- Batch-wise (timed) introduction;
- Flow-proportional injection;
- Modified flow-proportional injection (including line clearance).

Batch-wise introduction is normally avoided, as the mixing of product and additive cannot be guaranteed. Furthermore, one product is often delivered into multi-compartment
storage facilities on board a road tanker, possibly resulting in an overdose in one compartment and underdose in another.

If it is a simple case of injecting an additive into own loads and not injecting additive into competitor loads, then there is no problem with contamination, and the injection errors caused by switching between loads with and without additive are small provided that the volume between the injection point and the vehicle is small compared to the batch size. Hence simple direct ratio injection is acceptable.

However, different additives can be selected, greater care should be taken to avoid cross-contamination of additives. For these applications modified flow-proportional additive injection is employed. With this method no additive is injected before the final amount (say 200 liters) of the batch, thus leaving the loading linework purged of all additivated product.

1.4 GANTRY ADDITIVE INJECTION SYSTEM

1.4.1 Additive receipt facilities

To ensure that the correct additive is safely discharged and received into the right storage tank the following measures are taken:

11. Vehicle/rail discharge points are clearly marked to identify the additives in accordance with their delivery documents.
12. The systems for different types of additives and additives of competitors are kept completely segregated. Thus separate connections and pumping systems are used. Valve cross-overs are avoided. Dedicated connections are be employed wherever possible.

1.4.2 Additive storage vessel

The capacity of the storage vessel is determined by a number of aspects such as:

- The dosing rate;
- Annual throughput and seasonality;
- Stability;
- Premixing/dilution requirements (additive strength);
- Parcel size and security of supply.

In general the capacity of the vessel is sufficient for at least one month, in order to minimize additive handling activities.

The maximum capacity of the vessel required is determined by the parcel size and supply security of each specific additive as well as the additive shelf life. The maximum capacity is also often related to the seasonality of a particular product quality, e.g. cold flow properties for gasoils.

Pre-mixing of the additive by the supplier makes the on-site operating procedure simpler, but could add to the transportation costs. If mixing on site is selected then the quality control procedures shall be defined.

Depending on the physical and chemical properties of the additive, heating and/or insulation may be required. Care should be taken with the maximum storage temperature of many additives, in particular ignition improvers. Temperature alarms are provided, as well as e.g. water-spray cooling for fire protection or the use of underground storage tanks.

Tank mixers and tank filling/drainage facilities are provided.

For storage of light and/or toxic additives, pressure/vacuum valves are fitted to prevent emissions.
Means of establishing the amount of additive in the storage tank (dipping or level gauging) are provided to allow reconciliation of stocks.

1.4.3 Injection system

The systems can be categorized as follows:

1.4.3.1 Mechanical systems

Some Manufacturers deliver PD meters in which the additive injection mechanism is an integral part of the meter. A direct drive from the PD meter drives reciprocating additive pumps. The main advantage of this type of system is that it is simple and reliable and requires no power supply. However, the disadvantage is that the injection ratio is fixed and there is no guarantee that the additive is actually being injected. Therefore, additional safeguards are required such as an additive flow switch coupled to an alarm system.

1.4.3.2 Turbine driven injectors

A turbine wheel is installed in the main product flow. This mechanically drives a series of piston injectors, which are connected to an additive supply line held at a positive pressure. The system operates without an external power supply and is most useful where continuous proportional injection is required, such as dosing when product is delivered during receipt into storage.

1.4.3.3 Pneumatically driven injectors

The system basically comprises two units; a pneumatic transmitter and a piston pump unit.

The transmitter unit is normally positioned between the PD meter and the counter, and houses a simple gear train, which operates two whisker switches via a peg gear. These whisker switches send pneumatic signals to drive a shuttle valve, which in turn drives the pump unit.

These units are now tending to be replaced by their electronic counterparts, which are regarded as more reliable.

1.4.3.4 Electronic injector systems

These systems normally compromise four basic components, as shown below:

![Figure 1 – Typical Electronic Injector System](image-url)
13. An electronic pulse transmitter (often dual pulse), which is driven by the PD meter (turbine meter pulses or the signal of a Coriolis meter can be used directly).
14. A control unit, which acts as a pulse scaler, and also provides integral additive selection facilities.
15. An electro-mechanical piston injector, which is controlled by a pulsed output from the controller.
16. A pressurization pump, which pumps the additive to one or more injectors.
   The additive piston injector should be fitted with a proximity sensor, which sends feedback pulses to the controller, thus confirming that the injector is operating correctly. Depending on the control system these systems are capable of 'modified proportional injection' (e.g. line clearing).

1.4.3.5 Electronic flow-proportioning control

A typical system comprises:
17. An electronic pulse transmitter (single or dual pulse) fitted to the PD meter in the main loading line (this is regarded as the 'wild' flow by the additive controller).
18. A PD meter with electronic pulse transmitter located in the additive line, and a control valve located downstream of the meter (this is the 'controlled' flow). Coriolis mass flow meters may also be used for this purpose.
19. A ratio controller, which compares the measured "wild" flow signal and adjusts the "controlled" flow to provide the desired ratio. Typically this is via a combination of proportional and integration action (P and I).
20. Pressurization pump, which pumps the additive to one or more streams.
   Depending on the control system these systems are capable of "modified proportional injecting" (e.g. line clearing).

![Figure 2 – Electronic Flow Proportioning Control](image)

1.4.4 Injection nozzle

The additive injection point should be positioned upstream of the flow meter.

In general no problems are encountered with the design of the injection nozzle, as sufficient turbulence is created by meters, pipework etc. Static mixers may be used if insufficient mixing is suspected before on-line sampling takes place. The non-return valve (NRV) should be positioned as close as possible to the product rundown line. This will prevent the product from entering the additive line when the additive is not being injected. Should a next batch require additives, then the position of the NRV will ensure that the
additive is introduced into the product stream immediately after the injection system is started.
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