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Fiscal Metering Systems for North Sea Oil & Gas

Experience from Purchasing to Start-Up

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FISCAL METERING SYSTEMS FOR NORTH SEA OIL & GAS EXPERIENCE FROM PURCHASING TO START-UP.

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INTRODUCTION

The experience described in this paper reflects the experience of the authors from being involved in metering systems from different manufacturers both on the mechanical side and on the computer side.

The viewpoints and recommendations given here represent the opinion of the authors and do not necessarily reflect established procedures in their companies.

All viewpoints and recommendations expressed here are, in our opinion general and should be relevant to any manufacturer of metering systems.

The recommendations are aimed at both oil companies and metering equipment manufacturers.

You may ask:
What is so special about a metering system that three lectures are used at this workshop just to discuss its early life from purchase to start up? In fact, a number of people have put forward the question of what is so special about these metering systems. Very often, the question comes from project managers and procurement people in the development project organisation. If they don't get a good answer, they will know most of it at the end of the project:

- Complexity
  In spite of the simplicity of the basic principles of measurement, an offshore metering system as a whole may be a complicated package.

- Inadequate standards
  In spite of the fact that the design of the system is referred to as being in accordance with API or ISO standards, there are a number of important details not specified in the above standards.

- Approvals
  There are a number of "interested parties" to a fiscal metering system. Both law and commercial agreements give rights to these "parties" to approve the metering system. The "parties" having an interest in a fiscal metering system will be several or, in extreme cases, all of the following:

  - The buyer (Personell from the project team and also personell from his operating department.)
  - NPD (By Norwegian Law and regulations)
  - DoE (By international treaty if a "unified" reservoir)
  - The Norwegian Directorate of Legal Meteorology (onshore)
  - Pipeline operator (By transportation agreement)
  - Other "shippers" of hydrocarbons through the same multifield pipeline
  - Field partners

- No metering, no production
  You will normally not be allowed by NPD to start shipping of hydrocarbons from a field with the metering system faulty or not functioning.

Based on the above factors, it should be evident why careful attention must be paid to the metering system in all phases from purchasing into operation.

STAGES OF A METERING SYSTEM'S LIFE

We may split the process "FROM PURCHASING TO START UP" into 13 stages as tabulated below. This paper give viewpoints, in separate sections, which are relevant to those stages marked by an asterisk. In addition, the two last sections of the paper deals with two further aspects which are: NPD approval and relation between operations department/project team.

1.	Technical Specification for Bid Invitation	*
2.	Evaluation of Bids	*
3.	Bid Clarification Meetings	*
4.	Updating Technical Specification	
5.	Purchase Order	
6.	"Kick Off Meeting"	
7.	Fabrication	*
8.	Factory Acceptance Tests	*
9.	Preservation	*
10.	Shipping	
11.	Commissioning/on-site tests	
12.	Start	*

TECHNICAL SPECIFICATION FOR BID INVITATION

Ideally, this specification should specify all details of the system.

The advantage of writing a "tight" spec. is, of course, that you get exactly what you want. Also, it is much more easy to evaluate the different bids since there will not be any deviation between them, technically. With regard to bid evaluation, it is in particular beneficial to specify make and model of valves, accuracy of computing equipment, criteria for sizing the prover and required lengths of upstream tubing of gas meter runs. These details have great impact on cost. For example, full-bore valves may be twice as expensive as valves with reduced bore.

There are, however, disadvantages of writing a "tight" spec.: Firstly you will not benefit from the manufacturer's ability to optimize the system design and, secondly, you may make errors.

So, it is in our opinion important to request that the manufacturer in his bid also offer options which he considers more optimal and also that any errors in your specification are pointed out.

Also, when writing the technical details of the spec., you should always ask yourself if it would be possible to get what you want by making a functional requirement rather than a purely technical one.

A further point which should be carefully considered is whether or not to include any "specialised sub system" in the specification if the metering system vendor has no particular experience in the relevant technical area. What we have in mind when saying this are equipment like on-line chromatograph, automatic sampling systems etc. These subsystems may, functionally, be part of the fiscal metering but are, technically, very different from the flowmetering system. You may be better off by ordering such items separately, from a specialised company.

EVALUATION OF BIDS

Some viewpoints on the comparison of prices of the different bids:

- It is important that the prices are compared on a common basis. This means that the major items of the system must be of the same quality and price-class. If they are not, the comparison must take into account the additional costs or savings caused by the deviation from the desired quality-level. The major items where quality and price may differ are mainly valves, provers and computersystems.

- The rule of the project procedure is to select the lowest bid which satisfy the technical specification.

  This rule implies that a very tight (ideal?) specification has been written and that a very large amount of competent manpower is spent in the evaluation work. If not, it must be borne in mind that the lowest bid may not necessarily be the best. If a very low bid is selected, the manufacturer may have less freedom to implement the unavoidable minor changes of design during the project.

BID CLARIFICATION MEETINGS

No part of the clarification should be delayed till after the order has been issued. Even if the purchase order gets delayed beyond the project's schedule, sufficient time should be used to gain complete clarification of the bids. The advantages of getting a full clarification before the order is issued are evident:

- The buyer is in a better bargaining position in this stage.

- It is cheaper to do changes before design/fabrication has started.

- Even if you take some blows from the project manager because of upsetting the schedule, you will have to fight much harder for any change <u>after</u> the order.

The bid clarifications should always include a page-by-page review of the purchaser's technical specification, which means that the time required is more a matter of days than a matter of hours.

If your spec. was good enough, you may get off a lot easier, though.

FABRICATION

During this stage there will normally be held a series of technical clarification meetings and the buyer will follow up the progress of the fabrication process. We have some viewpoints and recommendations which apply to this.

Supervision of meteorological and operational characteristics

For the oil company, the manufacturer at this stage has a tendency to reveal a second personality. In the previous stages, the metering system was dealt with as an item where metrological qualities and operational characteristics had first priority.

When fabrication starts, the manufacturer gets into another gear where the above qualities are not so important compared to the new priority which is fabrication. From now on, all efforts are used to produce the items from which the system is to be put together. The purchaser may feel that there is little time and resources allocated to check the metrological qualities of the system that is put together.

For the oil companies, this is felt as a significant problem when buying a metering system. The causes and possible solutions to this problem were extensively discussed between the authors of this paper. Our recommendations are as follows:

- The specification and bid clarification should, in many cases, have been better. More and better work should have been done. In particular, the SMDL should include more drawings and documentation so that undesired design details can be detected as soon as possible after the drawing board. (SMDL = Supplier's Master Document List).

- The manufacturer should have a person in his organisation who has the time and competence to perform a continuous supervision of the manufactured items on the basis of metrological and operational characteristics of the full system. This person should have an obligation to make the buyer aware of any unintended consequences of buyer's spec. appearing as the system is put together.

This task can probably not be handled by the manufacturer's project leader since his first priority will, traditionally be to control the progress of fabrication and cost.

The right person to do this will be a competent metering engineer preferably with operational experience. To make sure that the right man and adequate resources are used, it may be beneficial to obtain an agreement on this as a separate item of the scope of work, specifying the name of the person to do the work.

Alternatively, this job might possibly be carried out by an extensive on-site follow up by competent personell from the buyer.

- To give a fast and correct answer to the vendor when a question or a problem arise in relation to metrological and operational characteristics, the buyer must have personell available to reply quickly. If answers or decisions are delayed, the manufacturer has to take a decision on the buyer's behalf to avoid delays in fabrication.

- The following basic rules should be established for the communication between buyer and manufacturer:

  . Stay on talking terms.

  . Avoid "ping-pong game" with telexes, instead make agreements verbally and <u>confirm</u> by telex.

- Have regular formal project meetings with a frequency of, say, once a month.

Problems with Delivery Schedule

In most cases, the delivery schedule for the metering package is critical for a platform project.

Problems with the delivery of metering packages have occurred in the past and we have tried to look into what the oil companies, on their part, can do to minimise the risk of this.

We believe that the following recommendations are particularly relevant for metering systems:

- If/when issuing change orders, always clarify if these have any "schedule impact".
  If the schedule is critical, don't issue any such change orders at all.

- Return reviewed drawings and documents to the manufacturer within the agreed time.

- Be aware that software may be a bottleneck. Avoid software functions that are too complicated, too extensive and too non-standard.

- Generally, establish structured and organised communication and working relationship with the vendor.

FACTORY ACCEPTANCE TEST

The factory acceptance test is the take-over test at the manufacturer's plant.

Normally, the completion of this test means that the customer gives his final approval of the metering system. All further work and testing will be outside the fixed price and strict time schedule of the purchase order.

It is therefore important that this test is properly conducted.

For many metering systems in the North Sea this has not been the case. The result has been that serious problems have occurred at start up.

Also, there is a tendency that the "non-fatal" errors remain uncorrected in the systems for years of operation.

By reviewing the problems known to us that has occurred during start up and operation, we have arrived at the following recommendations and afterthoughts for the factory acceptance tests:

- Test all equipment!
  At a FAT, the main activity (and problems) are very often concerned with the electronic equipment. Other important factors, such as operability and leak-tightness of orifice fittings, live checks of computers' control of valves etc. are often ignored. Considering how complicated it is to improve any machining of the inside of an orifice fitting when your system has come in operation, it is evident that a check or test of this and equivalent items should never be forgotten at the FAT.

- Allocate sufficient time to FAT!
  The main problem when doing a FAT is normally the time that you have available. Make sure that sufficient time has been allocated to FAT in the schedule of the order. You must then take into account the complexity of the system and also the time needed to rig up those computer systems that the metering computers shall communicate with. The most usual reason for insufficient time for the FAT is that the time schedule has been allowed to slip for activities before the FAT.

- Make a detailed test procedure!
  You cannot do a good test of a metering system just by improvising. The test must be carefully planned and a detailed procedure must be made in advance of the test. This procedure must describe precisely the method of the tests, equipment that is needed, its accuracy and the acceptance criteria/tolerances. The test procedure may be made either by the buyer or the manufacturer. It is, however, important that it is available for review/approval in ample time before the FAT.

  When doing the test, it is important that the procedure is followed and also that it has been allowed time for testing details that you find, when testing, is not included in the procedure.

- Use updated documentation!
  Make sure that all drawings and handbooks are updated and complete before the test.

- Prepare thoroughly before the test!
  From the buyer's side, an adequate amount of work must be made to get a full overview of the system before the FAT starts. The purchase order and any change orders must be carefully reviewed. The same goes for the manufacturers functional specification.

(The same applies of course, also for the test personell of the manufacturer.)

- Manufacturer must document his own tests!
  A major problem at FATs in the past has been that the manufacturer has not been thorough enough in his internal testing before the FAT.

  This has, in particular, been the case for the software of the computing system. As a result, a substantial part of the time at FATs has been used to diagnose errors and get them corrected.

  It is therefore very important that

  . The manufacturer do a proper test before FAT and

  . The results of this is documented and available to the buyer in ample time before FAT and

  . All test equipment the manufacturer has used is properly described and its calibration documented.

- Test the complete metering system!
  A serious shortcoming of the FATs has been that the computing system has been tested with a simulated connection or without a connection at all to the field equipment and to other platform computer systems.

  The "working environment" of the system has thus been very simplified when comparing it to the real life situation. This has probably been the largest shortcoming of most FATs in the past.

  On the other hand, it may be very time and cost consuming to arrange a FAT where the real working environment is present. We will nevertheless recommend the following:

- Bring along and test the system with all RTUs and SCADA-systems tied to it. (RTU = Remote Terminal Unit).

- For oil metering systems, do not make the full system test with simulated outputs/inputs from/to field equipment.

- For gas metering systems, check very carefully that the valve control signals match the valves and valve sequences required. To the extent that simulated inputs/outputs are used to/from field equipment, see that the simulation panel rigged up with satisfactory potentiometers and proper marking.

Keep discipline!

At the FAT, the buyer (and NPD) have their first full view of the system and its operational details.

In this kind of situation, it is very easy to produce a number of good ideas to improvements to a number of details that seem very easy to change on the spot.
(We are now referring mostly to the software functions.)
It is, however, very important to keep a very disciplined attitude in this respect both because of possible schedule impacts and because of that software changes implemented at the spur of the moment often get you into trouble by having adverse effects on other functions.

PRESERVATION

Normally, after shipping from the manufacturer, the metering system will be inactive for a substantial period before start up. It is necessary to take precautions against corrosion. This can be made by:

- All water after hydrostatic test or flow test must be drained out and the pipework must be thoroughly dried.

- Corrosion is prevented by filling the tubing with nitrogen at a slight overpressure. An adequate bottle supplying nitrogen continuously to the system as overpressure is decreasing, must be part of the shipped package.

- Alternatively, the inside of the tubing may be coated by special methods.

- All delicate parts are taken off the package and shipped/stored separately (Densitymeters, orifce plates).

Experience shows, however, that it is very often a problem to maintain preservation during the storage time.

If the pipework has too many/too large leaks, the nitrogen will have to be topped up at an unacceptable rate (once every 2 - 7 days for a large system). If the pipework is opened for inspection purposes, somebody has to remember to reestablish preservation.

In case of internally coated systems, one is dependent of pipework being properly dried and properly coated.

START

At start up of operation, the system will for the first time be exposed to a real - life working environment. A lot of situations which were not foreseen at the tests may occur. This means that errors may occur.

We can mention some examples known from the past:

- The flowcomputers stopped in situations when flow got small fluctuations.

- The computers did not manage to communicate when they got the full workload of responding to live signals and live PCDA system.

- Valve opening times was longer than programmed in software, error messages occurred all the time.

- Pulse duration for samplers were to short for the sampling system/pneumatic power as installed on the platform.

- Computers stopped because the platform powersupply gave small (within spec.) variations in voltage.

- Etc.

As regards operation of the system, the following is of importance at start up:

- Operators must be well trained.

- The system must have been designed to be simple to operate and easy to understand.

- The system must have an operator's manual. To day there is a tendency that the full functional spec. and operator's manual is combined in the same document. This is not good enough.

- A software engineer from the manufacturer and equipment to correct programs should be present on the platform at start up and during the first days of operation.

RELATION BETWEEN OPERATIONS DEPARTMENT AND PROJECT TEAM

Actually, within an oil company, traditionally there are two "interested parties" to the metering system. These are

- The project team and
- The operations department.

The project team has been organised to operate in a limited period of time and its function is to supervise and cooperate with the engineering contractor who purchases the metering system and handles it until it is installed on the platform.

The operations department is the actual "buyer" of the system and he is the one who will suffer if a bad system is installed.

It is therefore important that the operations department have a significant influence on the metering system from the bid evaluation stage and onwards. With due respect to all project engineers, it must be borne in mind that while the operations department is the one to live with the metering system in operation for a number of years, the project team/engineering contractor are normally through with their job when the system is mechanically complete on the platform and they "get their marks" on the basis of:

- Project costs and
- how well the schedule has been met.

A further aspect of involving the operations department in the process from purchasing to start up, is the transfer of operating experience into the project. In many cases the operations department has gained extensive experience with operation and maintenance of metering systems. Consequently they will be in a position where they may give valuable inputs to the project team/engineering contractor.

NPD APPROVAL OF DESIGN

If we take the NPD gas regulations as a basis, a metering system need the following approvals from NPD before start-up:

- Approval of design (NPD gas metering regul., ch. 5, para 41)
- Approval of system at manufacturer's site (NPD gas metering regul., ch. 6, para 49)
- Approval of system at area of application (i.e. platform) (NPD gas metering regul., ch. 6, para 49)

In this paper we will give some recommendations and viewpoints on the first of these approvals, i.e. approval of design. The two other approvals above, and other approvals needed (for procedures, safety etc.) are not dealt with here.

The first paragraph of chapter 5 of the NPD gas metering regulations reads as follows:

> "The design of the metering system shall be approved by the Norwegian Petroleum Directorate.
>
> Application for approval of the design of the metering system shall be submitted in a set of documents containing a complete technical description of the system. These documents shall contain the documents specified in this chapter. However, the Norwegian Petroleum Directorate may ask for supplementary informations."

This paragraph give the oil companies the right to apply for a approval of the design of the system at the early design stage, as soon as the required documentation (specified in paragraphs 42-47 of the regulations) is available.

For NPD it means that they have an obligation to approve or disapprove the system design.

It is highly recommended to the oil companies to apply for design approval of their metering system as early as possible in the design phase. At this stage, the costs of changing the design is small. If approval is applied for, and turned down, after the system has been built you may face a disaster both in terms of money and schedule delay.

The most common problem in doing this, is to get the technical documentation that you need for the application at an early stage. This may, however, be solved by including the appropriate requirements in the purchase order of the metering system.

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.