Associazione Italiana Strumentisti

ISA Italy Section

MISURE FISCALI

Milan, 25-10-2018

Auditorium TECNIMONT

Master Meter: ALL for ONE, ONE for ALL

Endress+Hauser

People for Process Automation

Andrea Calo'

All custody / fiscal metering systems have accuracy and repeatability targets which must be guaranteed during their entire life cycle under real working conditions

System Proving

Meter → **Prover**

System Proving consists in placing the duty meter in series with a meter prover having sufficiently better measurement accuracy and repeatability than the duty meter

Master Meter: ONE for ALL, ALL for ONE

Metering system at factory

high repeatability
high accuracy

Metering system in operation

(bad but possible cases)

low repeatabilty
low accuracy

high repeatability
low accuracy

- Process Conditions ; fluid, P, T, air etc..
- Measurement technology limits for mechanical meters (wear out, leakages..)

Metering system after Proving

high repeatability
high accuracy

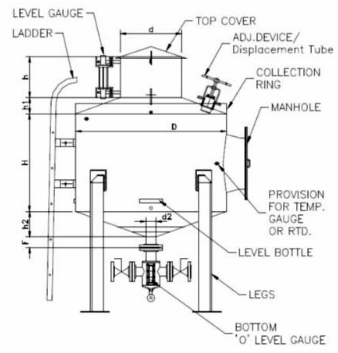
PROVING PROCESS

1. ***Meter Factor calculation*** = $\dfrac{\textit{Known Volume (Prover)}}{\textit{Unknown Volume (Duty Meter)}}$
2. ***Proving Validation criteria***

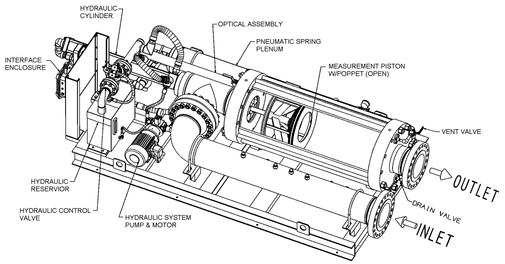
Reference International Standards for Proving MPMS Ch.4

Manual of Petroleum Measurement Standards Chapter 4—Proving Systems

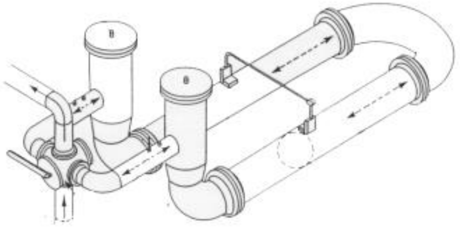
Open Tank Prover



Small Volume Piston Prover



Pipe Prover (Uni or Bi-Di)



Master Meter Prover

Focus on Master Meter Proving

Manual of Petroleum Measurement Standards Chapter 4—Proving Systems

Section 5—Master-Meter Provers

Measurement Coordination Department

FIRST EDITION, OCTOBER 1988

- Third Edition, June 2011

- Note: Latest issue is:
- Fourth Edition, June 2016

- **Master meter proving** is used when proving by the direct method can not be accomplished because of meter characteristics, logistics, time, space, safety, ***and cost considerations.***

- The terminology for this type of proving is "**Indirect master meter proving**"; according to MPMS Ch.4.5¶6.5 ,to establish a master meter factor (and this meter could be used for that duty), **a proving against a conventional prover on site or accredited calibration shall be performed** with a repeatability that results in a demonstrated random uncertainty of ±0.029 % or better, at a 95% confidence level.

- Our procedure for proving of the master meter to use it then on site normally uses a SVP with criteria of 0.05% repeatability in 5 runs : B+B in the table B.2 examples below:

Combinations	**Random Uncertainty (RU1)** Value of First Meter	**Random Uncertainty (RU2)** Value of Second	**MMF Range (spread)** Defined in 6.2 and 6.3	**Combined Uncertainty** MMF Uncertainty = $\sqrt{RU_1^2 + RU_2^2 + (0.5 \times \text{MMF Range})}$
A+B	0.011 %	0.027 %	0.05 %	0.054 %
A+C	0.011 %	0.073 %	0.10 %	0.124 %
C+B	0.073 %	0.027 %	0.15 %	0.153 %
B+B	0.027 %	0.027 %	0.05 %	0.063 %

Enable a meter to be a Master Meter

Proverdata	Oural crude										
diameter cm	wall thickness cm	elasticity	thermal exp.	linear exp.	waterdraw vol. liters						
43,19	5,08	1,931E+06	0,000346	0,0000172	94,6814						
ref. Density @15 degr.C	830,3	830,3	830,3	830,3	830,3		830,3	830,3	830,3	830,3	830,3
flowrate tons/hr	**160**	**160**	**160**	**160**	**160**		**140**	**140**	**140**	**140**	**140**
Omni report	**131**						**132**				
prove run	1	2	3	4	5		1	2	3	4	5
pulses	3891,29	3889,991	3891,06	3889,816	3889,305		3887,812	3888,376	3888,348	3887,883	3889,182
prover density kg/M3	819,533	819,504	819,473	819,44	819,402		819,234	819,213	819,193	819,166	819,14
temp. Prover deg.C	29,88	29,92	29,96	30	30,06		30,28	30,31	30,33	30,37	30,4
CTSp	1,000741	1,000742	1,000744	1,000745	1,000747		1,000753	1,000754	1,000755	1,000757	1,000759
CTLp	0,986697	0,986662	0,986625	0,986585	0,986537		0,98634	0,986315	0,98629	0,986258	0,986229
Press. prover Barg	4,02	4,0192	4,016	4,013	4,018		3,98	3,977	3,978	3,978	3,978
CPSp	1,000018	1,000018	1,000018	1,000018	1,000018		1,000018	1,000017	1,000018	1,000018	1,000018
CPLp	1,00034	1,00034	1,00034	1,00339	1,00034		1,000337	1,000337	1,000337	1,000337	1,000337
meter density kg/M3	819,664	819,631	819,602	819,571	819,531		819,35	819,326	819,309	819,287	819,257
temp. Meter deg.C	29,77	29,82	29,86	29,9	29,95		30,18	30,21	30,23	30,26	30,3
CTLm	0,986794	0,986753	0,986753	0,986681	0,986632		0,986429	0,9864	0,986378	0,986352	0,986316
press. Meter Barg	4,761	4,761	4,76	4,757	4,757		4,594	4,591	4,594	4,595	4,595
CPLm	1,000402	1,000402	1,000402	1,000402	1,000402		1,000389	1,000389	1,000389	1,000389	1,000389
correct prover volume l	94,753	94,753	94,754	94,754	94,754		94,754	94,754	94,755	94,755	94,755
prover mass kg	77,6534	77,6508	77,648	77,6449	77,6414		77,626	77,6241	77,6223	77,6199	77,6176
meter mass kg	77,8258	77,7998	77,8212	77,7963	77,7861		77,7562	77,767	77,767	77,7577	77,7836
meterfactor	**0,997785**	**0,998084**	**0,997774**	**0,998053**	**0,99814**		**0,998325**	**0,998155**	**0,99814**	**0,998228**	**0,997865**
final ref. Density"15 degr. C	833,22	833,22	833,22	833,22	833,22		833,22	833,22	833,22	833,22	833,22
density corr. Factor	1,003516801	1,0035168	1,0035168	1,0035168	1,003516801		1,0035168	1,0035168	1,0035168	1,0035168	1,0035168
vol. corr. Factor provervol.	1,001	1,001	1,001	1,001	1,001		1,001	1,001	1,001	1,001	1,001
(comp. To Maloney prover)											
meterfactor recalc	**1,000293718**	**1,00059347**	**1,00028269**	**1,00056239**	**1,00064961**		**1,00083508**	**1,00066465**	**1,00064961**	**1,00073783**	**1,00037392**
error	**0,029371772**	**0,05934695**	**0,02826901**	**0,05623916**	**0,06496103**		**0,08350754**	**0,0664648**	**0,06496103**	**0,07378316**	**0,03739189**
avg. Meterfactor	**1,000476376**						**1,00065222**				
repeatability +/-	**0,018346011**						**0,02305783**				
max. deviation	**0,036692023**						**0,04611566**				
viscosity kynematic cSt	**3,7**						**3,67**				
Reynoldsno:	**182173**						**160763**				
flowvelocity (measuring tube)	**13,16**						**11,52**				

∴ repeatability range = 0.037%

∴ repeatability range = 0.046%

4 inch meter oural crude | 4 inch meter arabian heavy | 4 inch meter dalia crude | curves 4 inch meter | 3 inch meter dalia

Enable a meter to be a Master Meter

N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
830,3	830,3	830,3	830,3	830,3		830,3	830,3	830,3	830,3	830,3		830,3	830,3	830,3	830,3	830,3
91	**91**	**91**	**91**	**91**		**60**	**60**	**60**	**60**	**60**		**25**	**25**	**25**	**25**	**25**
133						**134**						**135**				
1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
3888,388	3888,77	3888,527	3888,354	3888,476		3885,627	3885,874	3886,275	3885,952	3886,065		3885,751	3884,696	3885,271	3884,534	3884,364
819,046	819,025	819,007	818,994	818,966		818,881	818,859	818,821	818,775	818,736		818,666	818,626	818,586	818,548	818,512
30,53	30,56	30,59	30,61	30,64		30,77	30,81	30,85	30,92	30,97		31,07	31,13	31,18	31,23	31,28
1,000767	1,000768	1,00077	1,000771	1,000773		1,000781	1,000783	1,000786	1,000789	1,000792		1,000798	1,000802	1,000806	1,000811	1,000815
0,986109	0,986084	0,986062	0,986046	0,986013		0,985894	0,985866	0,985822	0,985766	0,985719		0,985626	0,985577	0,985529	0,985484	0,985441
4,025	4,029	4,028	4,024	4,027		4,211	4,212	4,215	4,215	4,212		4,305	4,309	4,306	4,304	4,302
1,000018	1,000018	1,000018	1,000018	1,000018		1,000019	1,000019	1,000019	1,000019	1,000019		1,000019	1,000019	1,000019	1,000019	1,000019
1,000342	1,000342	1,000342	1,000342	1,000342		1,000358	1,000358	1,000358	1,000358	1,000358		1,000367	1,00367	1,000367	1,000367	1,000367
819,139	819,108	819,094	819,079	819,056		818,959	818,932	818,896	818,849	818,81		818,743	818,701	818,668	818,627	818,593
30,44	30,48	30,5	30,52	30,55		30,68	30,72	30,77	30,83	30,88		30,98	31,03	31,08	31,13	31,18
0,986197	0,986158	0,986141	0,986123	0,986096		0,985976	0,985941	0,985898	0,985842	0,985795		0,985712	0,985661	0,985621	0,985573	0,985531
4,327	4,332	4,332	4,33	4,331		4,368	4,371	4,374	4,375	4,373		4,39	4,395	4,394	4,394	4,392
1,000367	1,000368	1,000368	1,000367	1,000368		1,000371	1,000371	1,000372	1,000372	1,000372		1,000374	1,000374	1,000374	1,000374	1,000374
94,756	94,756	94,756	94,756	94,756		94,757	94,757	94,758	94,758	94,758		94,759	94,759	94,76	94,76	94,76
77,6093	77,6074	77,6059	77,6022	77,6022		77,5948	77,5929	77,5896	77,5854	77,5819		77,5758	77,5722	77,5688	77,5656	77,5625
77,7678	77,7754	77,7705	77,7695	77,7695		77,7125	77,7175	77,7255	77,719	77,7213		77,715	77,6939	77,7054	77,6907	77,6873
0,997962	**0,99784**	**0,997882**	**0,997912**	**0,997848**		**0,998485**	**0,998397**	**0,998251**	**0,99828**	**0,998207**		**0,998208**	**0,998434**	**0,998241**	**0,99839**	**0,998394**
833,22	833,22	833,22	833,22	833,22		833,22	833,22	833,22	833,22	833,22		833,22	833,22	833,22	833,22	833,22
1,0035168	1,0035168	1,0035168	1,0035168	1,0035168		1,0035168	1,0035168	1,0035168	1,0035168	1,0035168		1,0035168	1,0035168	1,0035168	1,0035168	1,0035168
1,001	1,001	1,001	1,001	1,001		1,001	1,001	1,001	1,001	1,001		1,001	1,001	1,001	1,001	1,001
1,00047116	**1,00034886**	**1,00039096**	**1,00042104**	**1,00035688**		**1,00099548**	**1,00090726**	**1,00076089**	**1,00078996**	**1,00071678**		**1,00071778**	**1,00094435**	**1,00075086**	**1,00090024**	**1,00090425**
0,04711628	**0,0348856**	**0,03909616**	**0,0421037**	**0,03568761**		**0,09954777**	**0,09072565**	**0,07608894**	**0,07899623**	**0,07167788**		**0,07177813**	**0,09443495**	**0,07508642**	**0,09002389**	**0,09042489**
1,00039778						**1,00083407**						**1,0008435**				
0,00611534						**0,01393495**						**0,01132841**				
0,01223067						**0,0278699**						**0,02265682**				
3,64						**3,62**						**3,6**				
105382						**69880**						**29286**				
7,49						**4,94**						**2,06**				

∴ repeatability range = 0.012%

∴ repeatability range = 0.028%

∴ repeatability range = 0.023%

Operating of a Master Meter

Manual of Petroleum Measurement Standards
Chapter 4—Proving Systems

Section 8—Operation of Proving Systems

Measurement Coordination

FIRST EDITION, NOVEMBER 1995

- Note: Latest issue is:
- 2nd edition, September 2013

4.8.2.11 PROVER RECALIBRATION FREQUENCY

c. The maximum interval indicated below has elapsed.
  1. Three years for small volume provers and mobile provers.
  2. Five years for permanently installed pipe provers.
  3. Five years for permanently installed tank provers.
  4. Three months for master meter provers.

4.8.2.10 FREQUENCY OF METER PROVING

The frequency required for proving varies from several times a day to twice a year or even longer depending upon the value of the liquid, cost/benefit to prove, meter proving history, meter system stability, and variations of operating systems.

For large volumes or different liquids, a permanently installed prover is normally used. The meters should be proved whenever the flow rate, temperature, pressure, API Gravity (relative density), or viscosity changes significantly. Normally, time or volume is used to determine when the meter should be proved.

The proving frequency for new systems should start at short intervals and be extended to longer intervals as confidence increases in the system.

Coriolis Meter as best selection for Master Meter

- Best traceable accuracy and repeatability for top class products
- For top class products the traceable water calibration on the custody mass meter, is fully representative of the performance on oil product in the field then not affected by viscosity and density changes
- No wear out problems, no rotative part
- No need for P or T compensation for mass proving
- Suitable for mass and volume proving
- Compact and easy to be transported
- Faster proving than using displacement provers – and so can be used more often.
- Easier proving than using displacement provers – extremely easy to automate and so requires fewer skilled staff in the field.

Operating of a Coriolis Master Meter

- Coriolis meters shall comply with API MPMS Chapter 5.6.
- Prover meter factor for master meter proving of a mass meter using a mass master meter is calculated as below:

$$MF_P = \frac{M_{MM} \times MF_{MM}}{M_M}$$

MF_P	Meter factor calculated from proving	[-]
M_{MM}	Master meter (uncorrected) mass	[tonne]
MF_{MM}	Meter factor of the master meter (at the proving flow rate)	[-]
M_M	Meter on prove (uncorrected) mass	[tonne]

- Process conditions must ensure a single, homogenous fluid
- The meter factor that is determined during proving includes any error the zero value may be contributing. Prior to proving the line meter, but at the operating conditions (pressure and temperature) of the line meter, the master meter observed zero value should be verified.

Case study 1

Region: Far East Asia

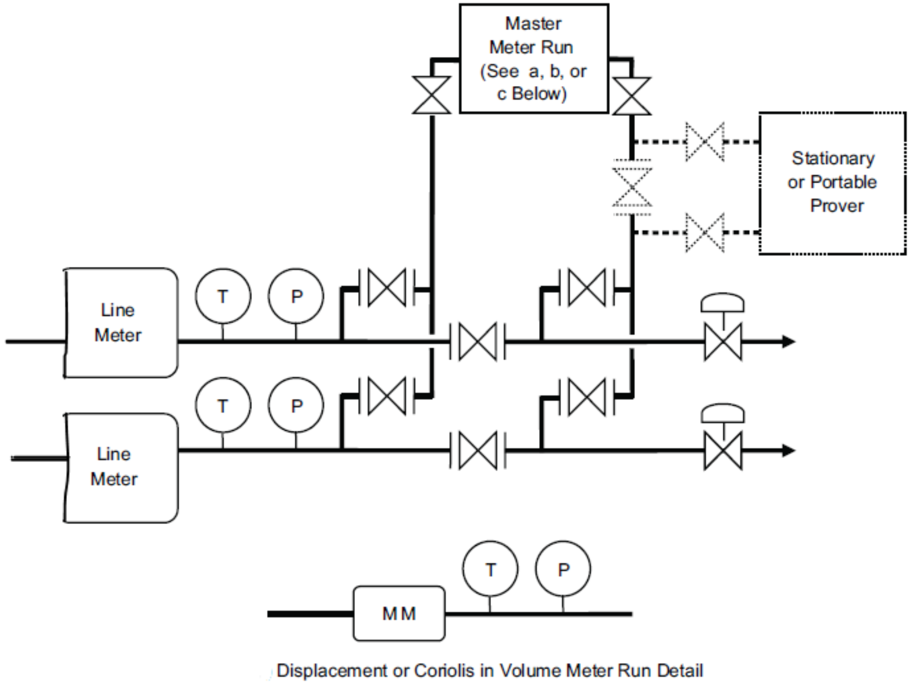
Customer Type: Refining

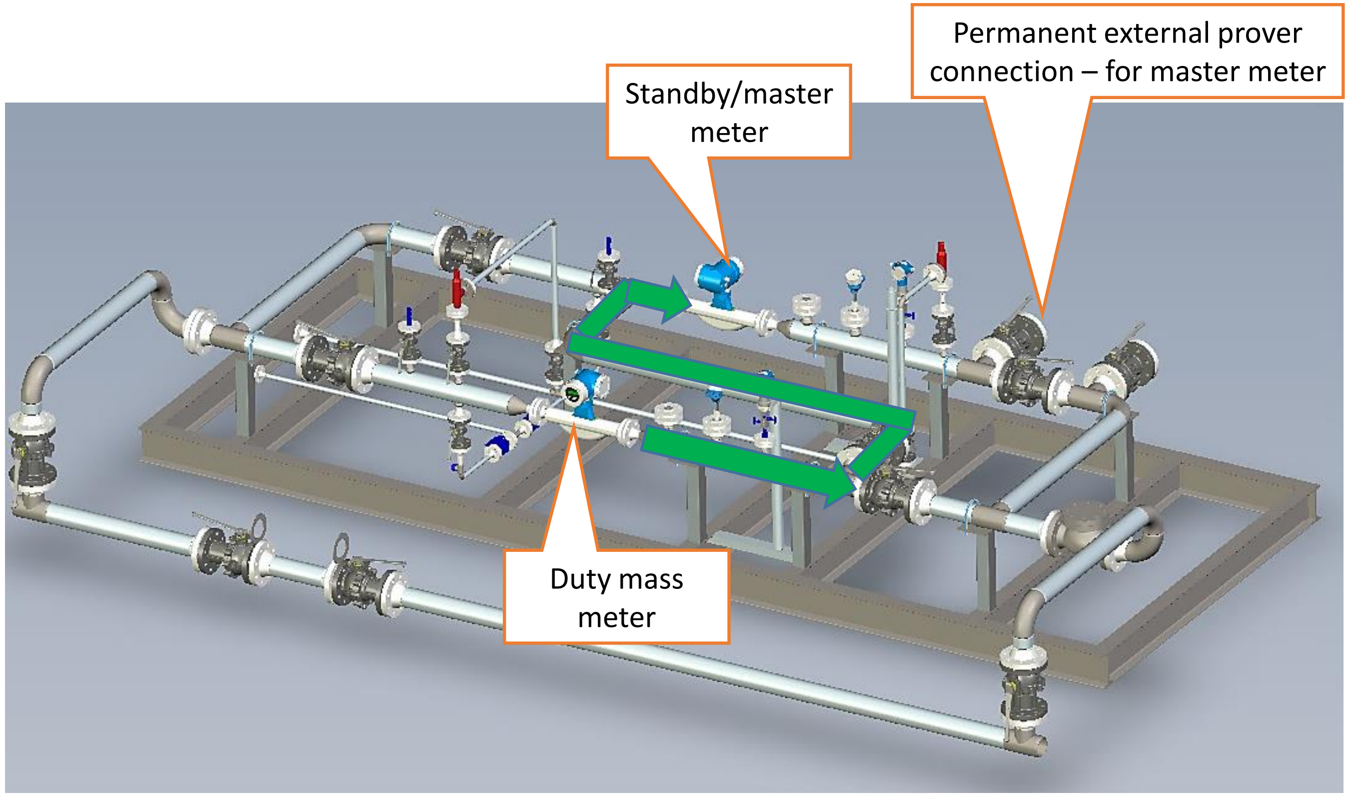
Application: LPG pipeline

Scope of supply :

- N'1 Custody Transfer LPG Pipeline Metering System class
- Z pattern configuration for master meter
- Fully automated proving process
- Fluid: LPG

Manual of Petroleum Measurement Standards
Chapter 4.5 Master Meter Provers





Z pattern / Pay & Check configuration

Approval of Weights & Measures on Site

- Various master-meter verifications at site initiated from control room – fully automated
- Then visit of SIRIM Berhad (wholly-owned company of the Malaysia Government), effectively, the weights & measures agency for Malaysia
- Validation also also from, NGC the end-customer

Shell
Port Dickson, Malaysia

Master Meter Report
29/Apr/2014 11:21

Validation start:	29/Apr/2014	11:16:21
Validation end:	29/Apr/2014	11:20:41

Flow Computer ID:	17-FC-251	**Prove result**	Completed
Report number:	26	**Meter factor status**	MF implemented

Meter data	
Meter tag nr	17-FCQ-270
Meter manufacturer	E+H
Meter model	PROMASS 84
Meter serial number	H905E602000
Meter size	1.5
K factor:	1000

Master Meter data	
Meter tag nr	17-FCQ-271
Meter manufacturer	E+H
Meter model	PROMASS 84
Meter serial number	H905E50200
Meter size	1.5
K factor:	1000

Conditions	
Required successful runs	3
Maximum nr of runs	5
Repeatability limit	1.000 %

Results	
Number of successful runs:	3
Number of performed runs:	3
Run repeatability:	0.322 %

	Mass		Pressure		Temperature		Flow rate	Meter factor
	Master	Test	Master	Test	Master	Test		
	tonne	tonne	bar(g)	bar(g)	°C	°C	tonne/hr	-
Run 1	0.31	0.31	14.55	15.57	40.33	40.47	16	1.000000
Run 2	0.31	0.31	14.61	15.42	40.16	40.32	15	0.996795
Run 3	0.31	0.31	14.37	15.56	40.10	40.25	18	1.000000
Average	**0.31**	**0.31**	**14.51**	**15.52**	**40.19**	**40.35**	**16**	**0.998932**

er factor	Value	Deviation %	Limit %	Result	
meter factor	0.998932			Passed	(Enabled)
ious meter factor	0.997850	0.11	0.25	Passed	(Enabled)
orical average	0.998974	0.00	0.25	Passed	(Enabled)
meter factor	0.998932	0.00	0.25	Passed	(Enabled)
rall				Passed	

rks:

Name: Mohd Sallehuddin Md Saad	Name: Zulfeizal Bedandin	Name: SYAHRUL MANAP		
Date: 29/4/14	Date: 29/4/14	Date: 29/4/14	29/4/14	
Signature:	Signature:	Signature:		
(SRCPD)	(NGC)	(NML - SIRIM)		

/2014 11:21 Page 1 of 1 Powered by eXLerate

Case study 2

Region: Europe

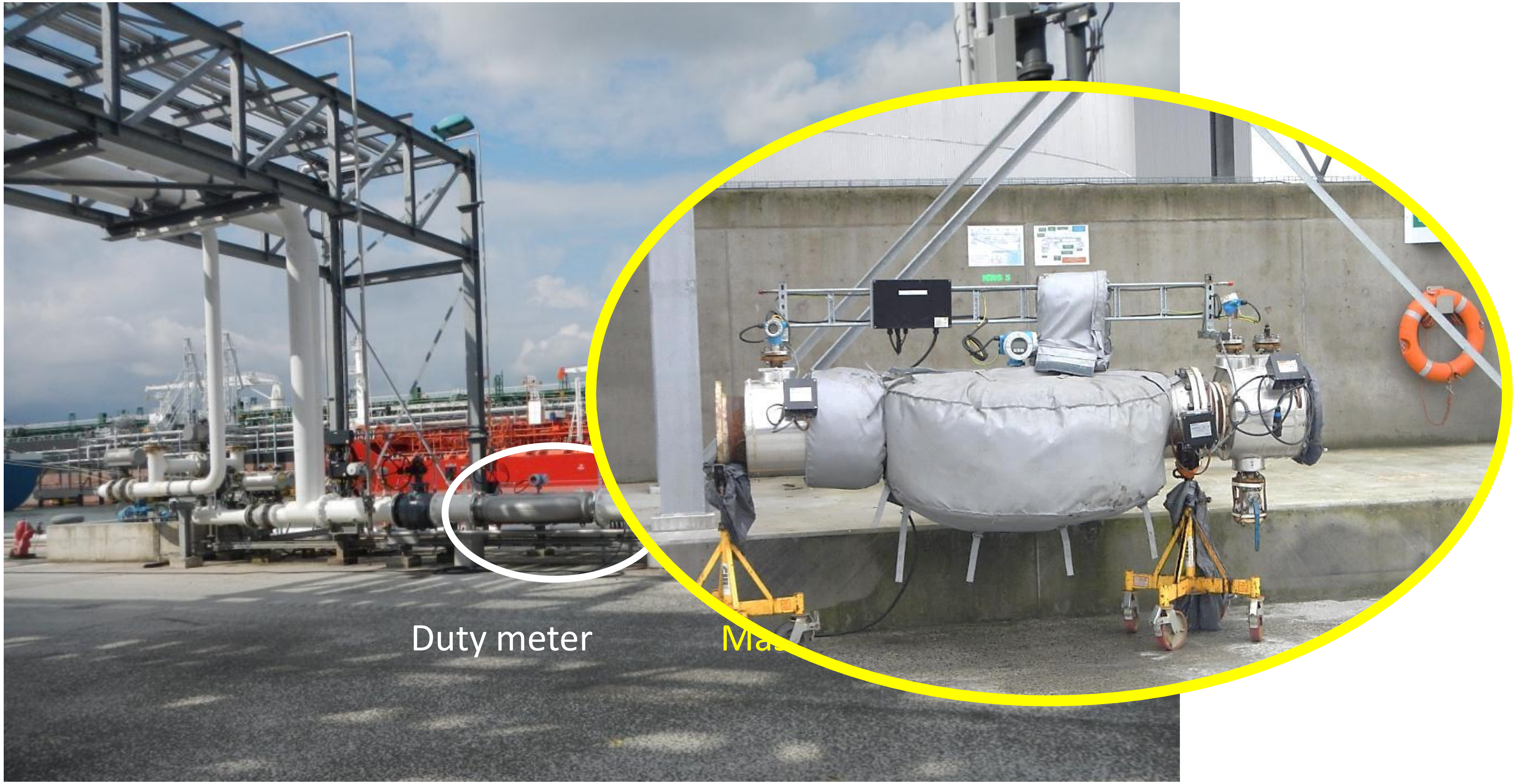
Customer Type: Market Terminal

Application: Ship Loading

Scope of supply :

- 9 off Custody Transfer MID 0.5 approved systems with Coriolis 12”
- 1 off Coriolis- 12” Master Meter MID approved on portable trailer
- Fluid: Gasoil, Heavy & Mid Bunker Fuel Oil – MGO IFO HFO

Master Meter: ONE for ALL, ALL for ONE



Master Meter: ONE for ALL, ALL for ONE

DUTY METER


DANAK
Calibration Certificate
FORCE TECHNOLOGY
Certificate No.: 9.4-14-18-0033
Task: 114-26878.02
Certificate date: 2014-10-31
Page: 1 of 1
Appendix: 2
Task specification: Product Verification
Customer equipment:
Make: Endress+Hauser
Type/Class: Promass 84 X3F-PAASFB61ABMN
Serial No.: PCN 80017505-4
Customer: Endress+Hauser
Address: Kaegenstrasse 2, 4153 Reinach, Switzerland

DANAK
FORCE Certification
Certificate of Conformity
Measuring Instrument Directive – MID, Module F
Certificate of conformity number: DK-0200-MI005-001-259.
Issued by FORCE Certification A/S, Denmark - EC-notified body number 0200
Issued to: Endress+Hauser Instruments International AG
Kaegenstrasse 2
4153 Reinach
Switzerland
Reference No.: 114-26878.02
Identification of the measuring system:
Type of instrument: Shipload measuring system
Type designation: Shipload measuring system J23
Serial number: PCN 80017505-4
EC-type examination certificate: DE-09-MI005-PTB035
Calibration certificate: 9.4-14-18-0033
Conclusion: The measuring system fulfils the requirements of the regulation.
Date of issue: Oktober 31, 2014
Lars Parmo
FORCE Certification, Certification Manager

MASTER METER


SPSE
CHAINE D'ETALONNAGE DEBITMETRIE LIQUIDE
LIQUID FLOW METER CALIBRATION
CERTIFICAT D'ETALONNAGE
CALIBRATION CERTIFICATE
N° 13377
DELIVRE A: Endress + Hauser
INSTRUMENT ETALONNE:
Désignation: Coriolis meter
Constructeur: Endress et Hauser
Type: PromassX 84X3F
Dimension: 12"
Date de réception: 15/07/2013
Date d'émission: 16/07/2013
LE RESPONSABLE DU LABORATOIRE
Michel FIEU
cofrac ETALONNAGE

- Calibration certificate for the duty meter for MID 0.5 application
- Certificate of conformity

- Calibration certificate from accredited laboratory using oil calibration rig with bi directional ball prover
- Yearly verification certificate against our accredited water calibration rig

Endress+Hauser
People for Process Automation

Associazione Italiana Strumentisti
ISA Italy Section

Case study 3

Region: Middle East

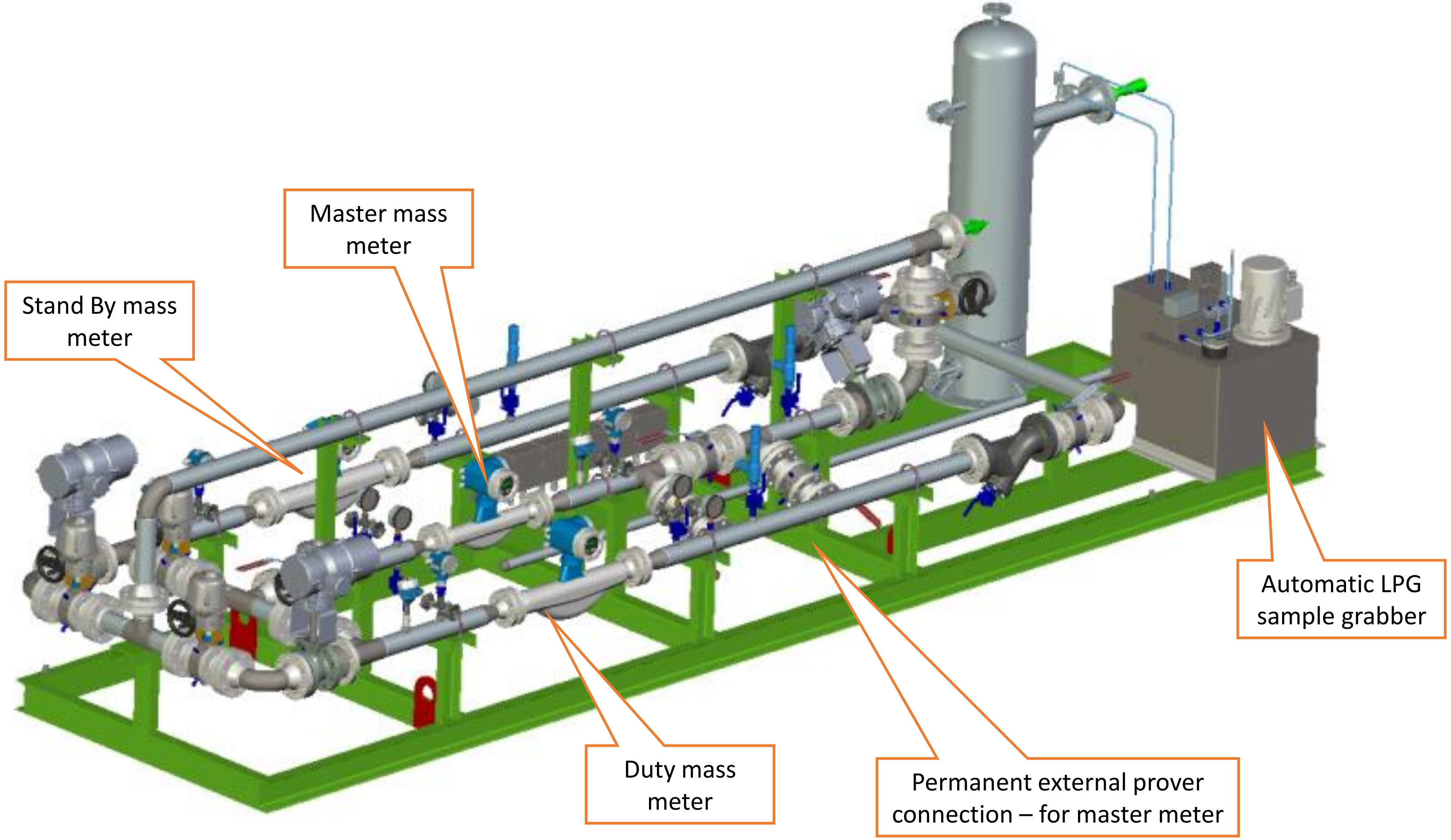
Customer Type: LPG production

Application: LPG pipeline

Scope of supply :

- 1 redundant custody transfer metering system
- 1 installed master meter
- Fully automated process including sampling and proving
- Fluid: LPG

Master Meter: ONE for ALL, ALL for ONE



Case study 4

Region: Africa

Customer Type: Distribution Terminal

Application: truck loading and pipeline metering

Scope of supply :

- 7 – Metering streams for LPG
- 3 – Metering streams for JET FUEL
- 3 – Metering streams for HEAVY GAS OIL
- 23 – Metering streams for GASOLINE
- 23 – Metering streams for GAS OIL
- 1 – Master meter

Case study 5

Region: Turkey

Customer Type: Terminals and Refinery

Application: Various , pipeline and ship loading/unloading

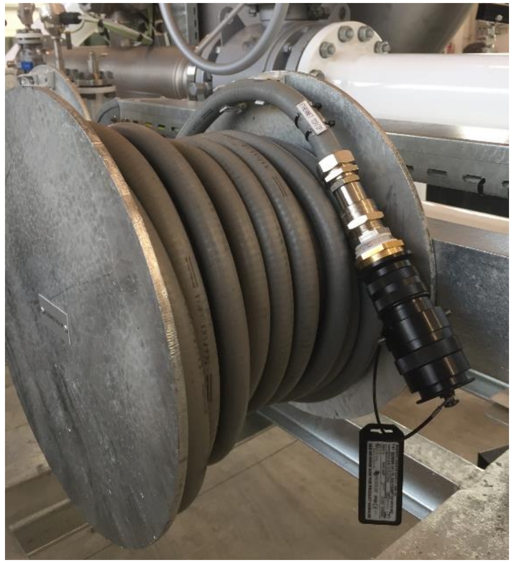
Scope of supply Project :

- Various custody transfer systems for different locations, applications and fluids
- 1 common master meter mounted on truck
- Fluid: Diesel , Gasoil ,LPG, HFO

Test of connection between master meter and metering skid with flexi pipes

Connection test

Grounding plug



Fast plug for signals

Easy to operate as first target in our design

Messages to bring home

- Master metering is a practical and recognized procedure for proving of custody transfer metering systems
- Coriolis meter new generation represent the most indicate and performant technologies for master metering:
  - Full independence from process conditions
  - Highest accuracy both for mass and volume measurement
  - Highest metering stability and repeatability
  - High turndown ratio in order to allow the multiple meter sizes proving with one common device
  - Compact footprint for easy installation on mobile provers

ONE Coriolis master meter

for

ALL proving needs

(....questions?)