INTERNATIONAL FORECOURT STANDARDS FORUM

STANDARD FORECOURT PROTOCOL
PART III.III
TANK LEVEL GAUGE APPLICATION VERSION 1.29 - March 2008

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Document Contents

0 Record of Changes

Only changes effected in Versions1.21 onwards are listed. Previous changes can be viewed in previous versions available in the Library, Standards Archive Section.

Date	Version number	Modifications
June 2002	1.21	Version changed from 1.20 to 1.21. Title, file name and footer changed. Date changed in title and footer modification. Record of changes. Tank Level Gauge Database:- Data Id 70. Text added. [1090] Data Id 71. Text added. [1090] TP Error Code Database:- Data Id 1. Text amended. [1090] Data Id 1. Text added. [1090] Tank Probe Database:- Data Id 22. Text amended. [1107]
February 2003	1.22	Removed contact details for IFSF Technical Support and made reference to the IFSF web site instead. Reduced Record of Changes section. **Chapter 3.1** Removed software download 'A1H'. **Chapter 3.7** Entire chapter removed.
March 2004	1.23	Comment added to all unsolicited messages stating they are without acknowledgment. **Chapter 2.1.3** Definition of "configuration data" added. **Chapter 3.2** Format of level corrected.
November 2004	1.24	**Chapter 3.2** Format of Diameter invented. Tank Probe Database:- Data Id 10. Field format amended. Format of level returned to original format.
January 2005	1.25	**Chapter 3.3.1** Note added to Date and Time, if application is running with other applications on same computer.
September 2005	1.26	**Chapter 2.1.3** Enter_Maint_Mode added. **Chapter 3.3.1** Data Id 70 made write in state 3, to accommodate "no error is generated when Enter_Maint_Mode is consecutively written". Added comment regarding resetting timer. Date Id 71 removed "no error is generated when Enter_Maint_Mode is consecutively written". **Chapter 3.4**. –TLG Error Code Data & Chapter 3.6 – TP Error Code Data Clarification of number of error codes to be returned. **Chapter 3.5.1** Data Id 100 (TP_Status_Message), typos, remove Read and Field type corrected to bin8 + bin16.
March 2006	1.27	**Chapter 3.5.1 Tank Probe Data** Additional text added to Data_Id 100 (TP_Status_Message) to clarify when the unsolicited message should be sent back.

		Chapter 3.4.1 & 3.6.1 Error Code Data Further clarification on which errors to send back and support.
May 2007	1.28	Document reformatted, no textual changes, only white space removed and footers and headers reduced in size to reduce length of document from 51 pages to 34 pages. **Chapter 3.2 Common Field Formats** Reference made to Engineering Bulletin No. 11.
March 2008	1.29	**Chapter 3.5.1** *Tank_Manifold_Partners* changed from bcd8 to bcd16 to make compatible with example. Config_Lock added. **Chapter 5.3** Handling of *Config_Lock* added. **Chapter 5.4** Handling after power down added.

1 INTRODUCTION

1.1 Definitions & Abbreviations

Definition	Abbreviation	Description
Controller Device	CD	The CD is any device that is capable of controlling other forecourt devices (i.e. *Dispensers*, *Tank Level Gauges*, *Outdoor Payment Terminals*, etc.)
Product	PR	The product is the motor fuel stored in the tank.
Local Node Address	LNA	The LNA is the address that identifies a device on the IFSF network. The LNA consists of two bytes (Subnet & Node Address). Please reference the IFSF document "PART II, COMMUNICATION SPECIFICATION" Release 1.4 for more details.
Tank Level Gauge	TLG	A hardware device that controls one or more tank probes. Up to 31 tank probes can be controlled from one Tank Level Gauge.
Tank Probe	TP	A hardware device which measures the product level of a tank. Some TP's are also capable of measuring the product temperature and the product density.

1.2 System Configurations

The terms Tank Level Gauge and Tank Probe mentioned in chapter 1.1 will be familiar to us all. They reflect the current setup of a tank gauging system where measurement probes (TP's) are linked to a central controller (the TLG). With the standardisation of data communication on forecourts the IFSF is looking towards the future of the industry. It is expected that, during the implementation of the protocol, advances will be made in the design of tank gauging systems.

The general trend in instrumentation is towards "intelligent" measurement devices. These devices are equipped with a processor, allowing them to perform their own data handling, calibration and other functions. The result of these developments will be the transfer of intelligence from the TLG towards the TP. These TP's can then be directly connected to the IFSF network, making the TLG hardware superfluous. The speed with which this transfer takes place will be dependent on the advances made in electronics, both from a technological and an economical standpoint. A complete switch-over in system configuration might not be possible, resulting in the intermediate step of intelligent TP's linked to an intelligent TLG.

The writers of the Tank Gauge Application Protocol recognise these developments, putting the Tank Probe centre stage. The complete document is written with the idea that the TP is directly linked to the IFSF network, as shown in figure 1 below. The behavioural model of a tank gauging system is therefore that of the TP and is described in chapter 2. Please note that a TP directly linked to the IFSF network will still need to have a TLG database implemented. Certain data elements will then need to be forced (see the table in section 3.3.2).

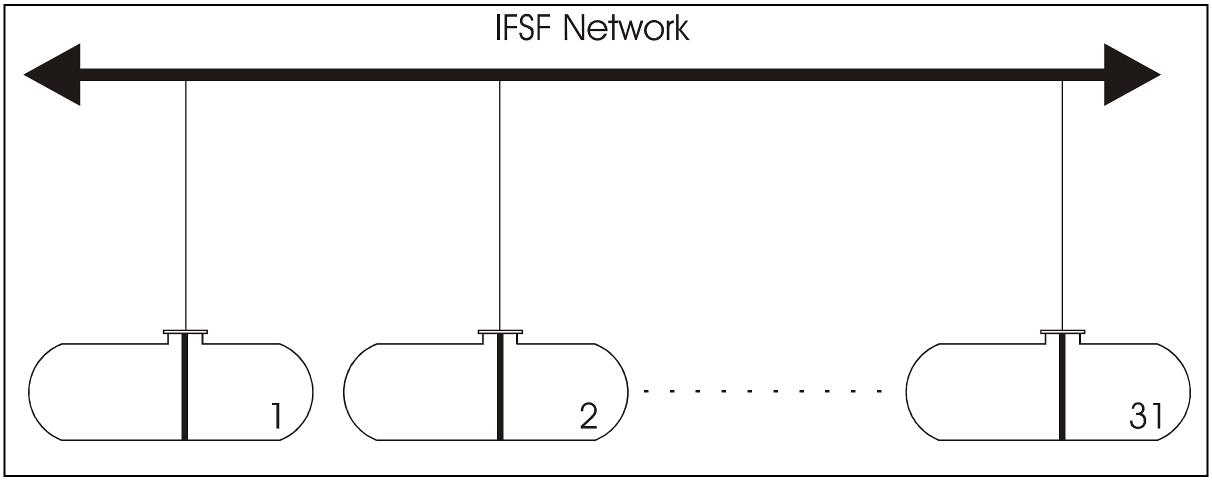


Figure 1 : IFSF Tank Gauging System Configuration

However, the writers have recognised that the first IFSF compatible tank gauging systems will be based on existing equipment. These systems have a TLG as the core unit and it's existence has to be accounted. A section of the system database is therefore reserved for TLG variables, allowing the TLG to be identified and configured. Regarding the behaviour of a "classic" TLG+TP tank gauging system, the behavioural model (based on the TP) remains valid. This means that these systems need to emulate the behaviour of the TP's linked to it as if the TLG is not there. This can be done by having "virtual TP's" inside the TLG controller, as shown in figure 2.

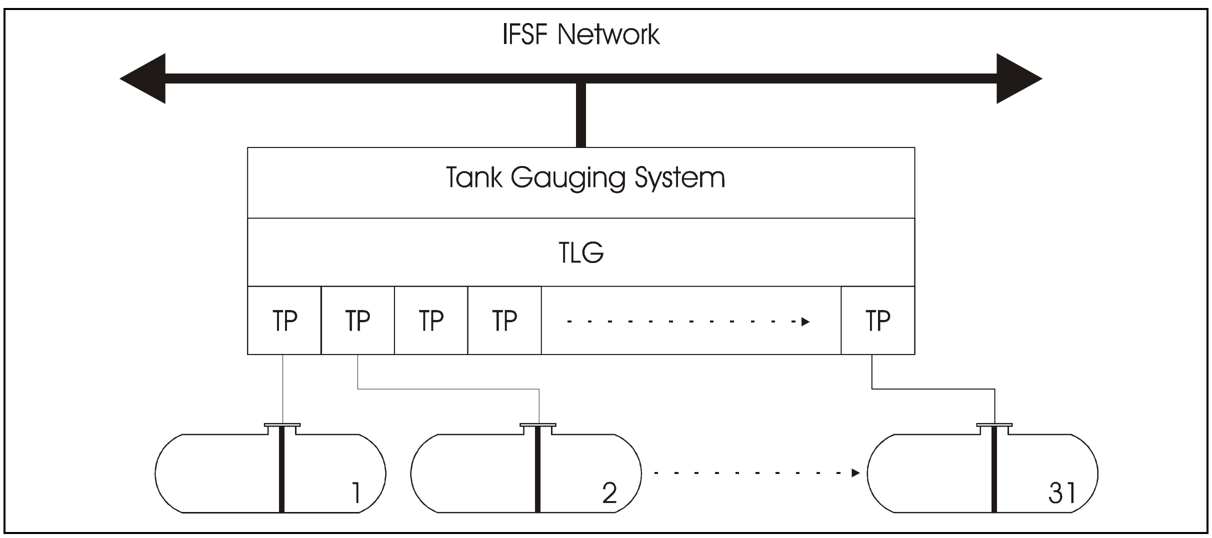


Figure 2 : Existing Tank Gauging System - IFSF Compatible

The inclusion of virtual TP's inside a TLG has some consequences for the tank gauging system as a whole. There will be some duplication of elements in the TP database. And, with regards to communication, an error inside the TLG can result in an error situation for all attached probes. In that case, TLG and TP error conditions will be signalled in a series of messages over the network. However, the development of intelligent TP's will mean that these disadvantages will disappear in time.

2 Tank Probe Behavioural Model

This chapter describes in detail each state, event and required actions of a tank probe gauge.

In the following description **STATES** are shown in bold text and "EVENTS" are given in double quotes. [Control flows] and [Data flows] are contained in square brackets.

The table below is used. Its content has the following definition.

STATE DESCRIPTION	
STATE IDENTIFIER NAME	A short description of the state.
EVENT DESCRIPTION	
"EVENT-NAME"	A short description of the event. Used to describe to which new state the tank probe has moved to, once all the actions are completed. --> Action: Input action description in terms of control and data flows between the CD and the TP. Action -->: Output action description in terms of control and data flows between the TP and the CD.

The data elements which are sent by the control and data flows are described in chapter 3 "Tank Level Gauge & Tank Probe Database".

Any change in the "Tank Probe State" is sent as an unsolicited message from the TP to the CD.
The CD recipient addresses for the unsolicited messages are contained in the "Recipient Address Table" in the Communication Service Database (for further information see chapter 4.5 in the document "Part 2-01, Communications Specification").

2.1 Tank Probe State Diagram

The tank probe state diagram describes in detail the behaviour of the tank probes connected to the tank level gauge.

States are represented on Figure 3 (Tank Probe State Diagram) and Figure 4 (Tank Probe State Diagram - Error Conditions) by rectangles. The states are sequentially numbered.

The arrows between the states are labelled with the event name or names that causes the TP to change from one state to another. The direction of state transfer is indicated by the arrowhead.

In Figure 5 all states and events are combined in a matrix.

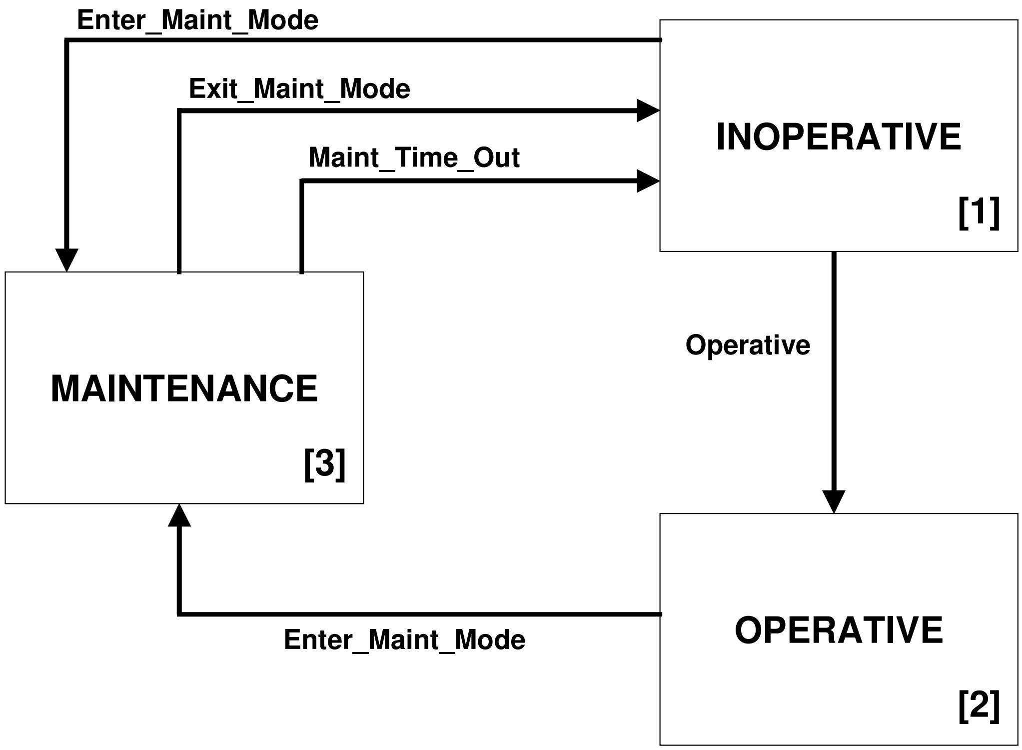


Figure 3 : Tank Probe State Diagram

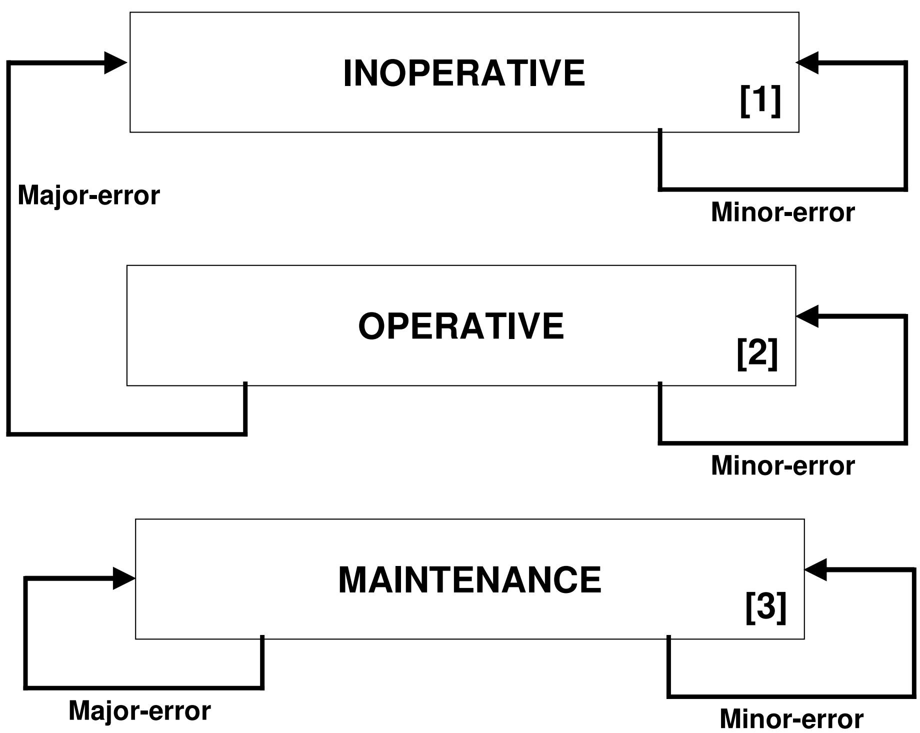


Figure 4: Tank Probe State Diagram – Error Conditions

State Event	1 Inoperative	2 Operative	3 Maintenance
Operative	--> 2	2	3
Enter_Maint_Mode	--> 3	--> 3	3
Exit_Maint_Mode	-	-	--> 1
Maint_Time_Out	-	-	--> 1
Major-error	1	--> 1	3
Minor-error	1	2	3

Figure 5 : Tank Probe State Table

Description

n	no state change
-> n	State changes to state n
-	not applicable

2.1.1 State Inoperative [1]

STATE DESCRIPTION	
INOPERATIVE	The TP is in the **INOPERATIVE** state when it is not possible to function. The reason for this is that essential operational data is missing or a major error has been detected.
EVENT DESCRIPTION	
"OPERATIVE"	When the TLG & TP have been configured with the essential data to operate, the TP has a reading and no major errors are detected (see 3.11 Error Code Data), the TP goes to the state **OPERATIVE**. Action -->: The TP state change is sent as an unsolicited data array [TP_Status_Message].
"Enter_Maint_Mode"	The TP is forced to move to the **MAINTENANCE** state. Action -->: The TP sends the unsolicited data [TP_Status_Message].
"MINOR ERROR"	If a minor error event occurs the TP does not change state. Action -->: The TP sends the unsolicited data [TP_Error_Type].

2.1.2. State Operative [2]

STATE DESCRIPTION	
OPERATIVE	The TP is completely configured, has tank readings and no major error is detected. The TP must respond to all communications from controller devices.
EVENT DESCRIPTION	
"Enter_Maint_Mode"	The TP is forced to move to the **MAINTENANCE** state. Action -->: The TP sends the unsolicited data [TP_Status_Message].
"MAJOR-ERROR"	If a major error event occurs the TP moves into state **INOPERATIVE**. Action -->: The TP sends the unsolicited data [TP_Error_Type]. The TP sends the unsolicited data [TP_Status_Message].
"MINOR-ERROR"	If a minor error event occurs the TP does not change state. Action -->: The TP sends the unsolicited data [TP_Error_Type].

2.1.3 State Maintenance [3]

STATE DESCRIPTION	
MAINTENANCE	The TP is in maintenance mode where important/critical data can be modified and software downloaded. The Maintenance mode can only be entered when the maintenance password is known.
EVENT DESCRIPTION	
"Enter_Maint_Mode"	The TP remains in **MAINTENANCE** state. Action -->: The TP sends the unsolicited data [TP_Status_Message].
"Exit_Maint_Mode"	The TP is forced into the **INOPERATIVE** state. Action -->: The TP state change is send as an unsolicited data array [TP_Status_Message].
"Maint_Time_Out"	When no configuration data (DB_Ad 01H and DB_Ad 01H+41H) changes and/or software download takes place after the TP has been forced into maintenance mode, the TP will automatically be forced into the **INOPERATIVE** state. The time-out period is fixed at 5 minutes. Action -->: The TP state change is send as an unsolicited data array [TP_Status_Message]. Action -->: The TP sends an unsolicited data array [TP_Error_Type] with minor error Maint_Time_Out to the CD and the error is stored within the TR_Error_Code.
"MAJOR ERROR"	If a major error event occurs the TP does not change state. Action -->: The TP sends the unsolicited data [TP_Error_Type].
"MINOR ERROR"	If a minor error event occurs the TP does not change state.

	Action -->: The TP sends the unsolicited data [TP_Error_Type].

3 Tank Level Gauge & Tank Probe Database

This part of the document details the standard data organisation for a Tank Gauging System.

Every data element in the TLG & TP data base is described in this chapter. The access to the data element is done by a Database Address "DB_Ad" and a Data_identifier "Data_Id".

The data fields are presented in the following form:

DATABASE DB_Ad =				
Data_Id	*Data Element Name* Description	Field Type	Read/Write in State	M/O

Data_Id

The Data_Id is an unique identifier for a data element in a database. The database is defined by the database address "DB_Ad" (for details see document "Part II, Communication Specification").

Data Element Name

In the second column the name of the data element is defined. In this column is also the description of the data element.

Field type

The field types in the column three are described in Chapter 3.2 of this document.

Read/Write in State

The "Read/Write in state" column indicates if the related data can be Read and/or Written by any device and in which Tank Probe state (states are indicated between brackets).

M/O

The "M/O" column (Mandatory/Optional) indicates if the data element must be supported / implemented by the Tank Probes and any Controller Devices controlling the Tank Probes. "M" indicates that the data element must be supported, "O" indicates that the data element is optional. Note: All mandatory data elements must be supported/implemented for a device to be IFSF compatible.

The mandatory data elements describe the bare minimum implementation requirements for a basic tank level gauge that can only measure fuel and water height. These consist of a set of IFSF protocol overhead elements, control functions, status messages, error codes, and the two height measurements.

Since many available tank level gauges are capable of more than this, the optional elements have been divided into groups that identify additional functionality. This will allow a customer to specify the optional groups that are required for an intended application. These are not intended to be levels of ascending complexity. For example, it would be acceptable to implement Option Group 3" without having implemented Option Group 1".

Here is a description of the Option Groups:

- O - These are individual optional elements that are not part of an identified group, including some that are only necessary for certain types of gauges.
- O1 - This group identifies gauges that are capable of timekeeping and record dating.
- O2 - This group identifies gauges that have implemented the fuel and water height threshold alarms.
- O3 - This group identifies gauges that are able to calculate the volume of the contents of the tank.
- O4 - This group identifies gauges that have implemented the volume threshold alarms.
- O5 - This group identifies gauges that are capable of measuring fuel temperatures and calculating temperature compensated volumes.

3.1 Data Address

The different records described here are accessible through an **address** which is defined in the following way (more details are in the document "PART 2-01, COMMUNICATION SPECIFICATION").

DDV_Ad & SDV_Ad							
BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5	BYTE 6	BYTE 7	BYTE 8
COMS_SV 00H Communi-cation Service Data							
TLG_DAT 01H Tank Level Gauge Data	TLG_ER_DAT 41H Error Data.	TLG_ER_ID 01H-40H Error Identifier					
TP_ID 21H-3FH Tank Probe Identifier (1-31)	CAL_DAT 21H Calibration Data.	ENTRY 01H-FFH Entry point into the calibration table.					
	TEMP_DAT 22H Temperature Data.	ENTRY 01H-08H Address of Temperature Data.					
	TP_ER_DAT 41H	TP_ER_ID 01H-40H					

DDV_Ad & SDV_Ad							
BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5	BYTE 6	BYTE 7	BYTE 8
	Error Data.	Error Identifier					

3.2 Common Field Formats

IFSF Application field formats are given in Engineering Bulletin No 11. The following statement is made for fields of type LONG_TEMP, LONG_VOLUME, LEVEL and DIAMETER.

Field	Format	Description
LONG_TEMP	bin8 + bcd6	Temperature value (used for fuelling transaction data). The default Long_Temp format for Tank Gauges is 6,3 (i.e. 999.999). When generating a Long_Temp field the following data should be sent (in bcd format): xx,04,03,12,34,56 Where xx= Data_Id.
LONG_VOLUME	bin8 + bcd12	Volume value (used for totals). The default Long_Volume format for Tank Gauges is 12,3 (i.e. 999999999.999). When generating a Long_Volume field the following data should be sent (in bcd format): xx,07,09,12,34,56,78,90,12 Where xx= Data_Id.
LEVEL	bcd8	Level value (as used for level readings by tank level gauges). This is an integer value of increments of the resolution detailed in the following table, according to the Units of Measurement used, eg: Metric level would be reported in 0.001 mm (one thousandth of a mm). US or Imperial level would be reported in 0.0001 inch (one ten thousandth of an inch).
DIAMETER	bcd8	Diameter Value is an integer value of increments of the resolution detailed in the following table, according to the Units of Measurement used, eg: Metric diameter would be reported in 0.001 mm (one thousandth of a mm). US or Imperial diameter would be reported in 0.0001 inch (one ten thousandth of an inch).

In the data descriptions that follow, the Units of Measurement should be interpreted as follows:

	METRIC		US		IMPERIAL	
Field	units	resolution	units	resolution	units	resolution
Level	mm	0.001	inches	0.0001	inches	0.0001
Diamet	mm	0.001	inches	0.0001	inches	0.0001

er						
Temp	deg C	0.01	deg F	0.01	deg F	0.01
Volum e	litres	0.01	Galls (US)	0.01	Galls (UK)	0.01

The default Units of Measurement is METRIC.

3.3 Tank Level Gauge Data

3.3.1 Tank Level Gauge Database

This data allows a CD to configure the TLG. As the TP can be linked directly to the IFSF network the TLG data elements must be handled in a special way by the TP (see chapter 3.3.2).

TANK LEVEL GAUGE DATABASE DB_Ad = TLG_DAT (01H)				
Data_Id	***Data Element Name*** Description	Field Type (Values)	Read / Write in State	M/O
CONFIGURATION DATA				
1 (01H)	***Nb_Tanks*** Number of tanks defined. 0 = not configured n = number of tanks Please see 3.3.2 Please note that TLG's that do not permit the *Nb_Tanks* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Nb_Tanks* to the number of tanks that is hard coded in their program. When a master reset/coldstart occurs on the TLG device the TLG should reset this Data_Id to its default value.	bin8	R(1-3) W(3)	M
2 (02H)	***Reference_Temp*** This temperature value is used in the calculations to adjust the *Total_Observed_Volume* into the temperature corrected *Gross_Observed_Volume*. In Europe a reference temperature of 15 °C is used. In the U.S.A. the reference temperature is 60 °F. Please see 3.3.2 Please note that TLG's that do not permit the *Reference_Temp* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Reference_Temp* to the value that is hard coded in their program. When a master reset/coldstart occurs on the TLG device the TLG should reset this Data_Id to its default value.	TEMP	R(1-3) W(3)	O5

TANK LEVEL GAUGE DATABASE
DB_Ad = TLG_DAT (01H)

Data_Id	***Data Element Name*** Description	Field Type (Values)	Read / Write in State	M/O
3 (03H)	***TLG_Measurement_Units*** The *TLG_Measurement_Units* specifies the units in which all data will be reported: 0 – metric 1 - US units 2 - imperial units Please note that TLG's that do not support the *TLG_Measurement_Units* should report everything in metric units. When a master reset/coldstart occurs on the TLG device the TLG should reset this Data_Id to metric.	bin8	R(1-3) W(3)	O
6 (06H)	***Country_Code*** Country where the tank level gauge is installed. A value of 0000 or 9000 means country independent. If the first digit is a 9 then the three digits country code from ISO 3166 is used, otherwise the PTT call dialling code is used. Please refer to Engineering Bulletin "Handling of Country Codes". If the PTT dialling code is less than four digits a further naught (zero) should be added in front of the existing three, e.g. 063 is input as 0063. If it is more than four digits then input from the right, e.g. 00942 is input as 0942. Please note that TLG's that do not permit the *Country_Code* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Country_Code* to the hard coded country code value. When a master reset/coldstart occurs on the TLG device the TLG should reset this Data_Id to its default value.	bcd4	R(1-3) W(3)	M

TANK LEVEL GAUGE DATABASE DB_Ad = TLG_DAT (01H)				
Data_Id	***Data Element Name*** Description	Field Type (Values)	Read / Write in State	M/O
7 (07H)	***Maint_Password*** This is the password required to force the TP into maintenance mode. It needs to be issued before the *Enter_Maint_Mode* command. The TLG must compare the new password with the currently stored password. If they are the same then an *Enter_Maint_Mode* command will be accepted within the 5 minute timeout period. Note that in the case that a write action occurs in the Inoperative or Operative states with a *Maint_Password* different to the stored password, the TLG must reject the attempt with a *Data_Ack* value 6 (Command not accepted). Note that no error is generated when *Maint_Password* is consecutively written. Also note that a write action for *Maint_Password* when in maintenance mode results in the updating of the password value. The sequence of write actions for a change in password value is therefore the following: 1st Maint_Password (old value) 2nd Enter_Maint_Mode 3rd Maint_Password (new value) 4th Exit_Maint_Mode Also note that the password cannot be read back in any of the TP states, to prevent tampering with the TP setup. The manufacturer of the tank gauging system should therefore take care of an emergency provision to enter maintenance mode when the *Main_Password* is not known. Please see 3.3.2	asc6	W(1-3)	M
50 (32H)	***TLG_Manufacturer_Id*** To allow the CD to interrogate the TLG manufacturer's identity (as registered with the IFSF). Please see 3.3.2	asc3	R(1-3)	M
51 (33H)	***TLG_Model*** To allow the CD to interrogate the TLG model. Please see 3.3.2	asc3	R(1-3)	M
52 (34H)	***TLG_Type*** To allow the CD to interrogate the TLG type. Please see 3.3.2	asc3	R(1-3)	M
53 (35H)	***TLG_Serial_Nb*** To allow the CD to interrogate the TLG's serial number. Please see 3.3.2	asc12	R(1-3)	M
54 (36H)	***TLG_Appl_Software_Ver*** To allow the CD to interrogate the version number of the TLG application software. The *TLG_Appl_Software_Ver* number format is '9999999999.99'. Please see 3.3.2	asc12	R(1-3)	M

TANK LEVEL GAUGE DATABASE DB_Ad = TLG_DAT (01H)				
Data_Id	***Data Element Name*** Description	Field Type (Values)	Read / Write in State	M/O
58 (3AH)	***IFSF_Protocol_Ver*** To allow a CD to interrogate the IFSF 'Tank Gauge Application Protocol' version number. The *Protocol_Ver* number format is '9999999999.99'. Please see 3.3.2	bcd12	R(1-3)	M
59 (3BH)	***Current_Date*** To allow the CD to interrogate and/or set the current date of the TLG. Where the Tank Level Gauge application is running on a computer with other applications (e.g. on a back office PC), setting the Date and Time should be done using the computer supplied facility. In this case, the Tank Level Gauge application should reject any write attempts with a Data_ACK value of 2 (Read only/ Not Writable). Please see 3.3.2	DATE	R(1-3) W(1-3)	O1
60 (3CH)	***Current_Time*** To allow the CD to interrogate and/or set the current time of the TLG Where the Tank Level Gauge application is running on a computer with other applications (e.g. on a back office PC), setting the Date and Time should be done using the computer supplied facility. In this case, the Tank Level Gauge application should reject any write attempts with a Data_ACK value of 2 (Read only/ Not Writable). Please see 3.3.2	TIME	R(1-3) W(1-3)	O1
61 (3DH)	***SW_Checksum*** To allow the CD to interrogate the checksum of the software. The field format is HHHH. Where: HHHH consists of four hexadecimal digits (ASCII 0-9,A-F).	asc4	R(1-3)	M
TLG COMMAND				
70 (46H)	***Enter_Maint_Mode*** Forces the TP to go into the Maintenance mode. It is only possible to enter into maintenance mode when the *Enter_Maint_Mode* command is preceded by the *Maint_Password* data element. Note that no error is generated when *Enter_Maint_Mode* is consecutively written. Whenever *Enter_Maint_Mode* is written the 5 minute timer is reset. Please note that unsolicited (without acknowledge) data *TP_Status_Message* is transmitted as a result of a state change. Please see 3.3.2	CMD	W(1-3)	M

TANK LEVEL GAUGE DATABASE DB_Ad = TLG_DAT (01H)				
Data_Id	***Data Element Name*** Description	Field Type (Values)	Read / Write in State	M/O
71 (47H)	***Exit_Maint_Mode*** Forces the TP to exit from the Maintenance mode. Please note that unsolicited (without acknowledge) data *TP_Status_Message* is transmitted as a result of a state change. Please see 3.3.2	CMD	W(3)	M
MANUFACTURER / OIL COMPANY SPECIFIC				
200 to 255	Free to the manufacturer / oil company			

3.3.2 TLG Data_Id Support

A description was made in chapter 1.2 of the two possible configurations for linking TP's to the IFSF network. When the TP is directly connected to the IFSF network, a number of the elements in the TLG database need to be handled in a special manner. The table below details the elements of the TLG database.

TLG Database Element Support			
Data element name	M/O	TP via TLG on network	TP directly on network
NB_Tanks	M	*NB_Tanks*	*NB_Tanks = 1*
Reference_Temp	O	*Reference_Temp*	*Reference_Temp*
TLG_Measurement_Units	O	*TLG_Measurement_Units*	*Set equal to TP_Measurement_Units*
Country_Code	M	*Country_Code*	*Country_Code*
Maint_Password	M	*Maint_Password*	*Maint_Password*
TLG_Manufacturer_Id	M	*TLG_Manufacturer_Id*	Set equal to *TP_Manufacturer_Id*
TLG_Model	M	*TLG_Model*	Set equal to *TP_Model*
TLG_Type	M	*TLG_Type*	Set equal to *TP_Type*
TLG_Serial_Nb	M	*TLG_Serial_Nb*	Set equal to *TP_Serial_Nb*
TLG_Appl_Software_Ver	M	*TLG_Appl_Software_Ver*	Set equal to *TP_Appl_Software_Ver*
IFSF_Protocol_Ver	M	*IFSF_Protocol_Ver*	*IFSF_Protocol_Ver*
Current_Date	O	*Current_Date*	*Current_Date*
Current_Time	O	*Current_Time*	*Current_Time*

Enter_Maint_Mode	M	*Enter_Maint_Mode*	*Enter_Maint_Mode*
Exit_Maint_Mode	M	*Exit_Maint_Mode*	*Exit_Maint_Mode*

3.4 Tank Level Gauge Error Code Data

3.4.1 TLG Error Code Database

This data allows the CD to handle the error data from a TLG.

The TLG_ER_DAT = 40H is used to ask for all TLG error code data. Please note the TLG returns all defined error codes in the below list (01H to 05H and 20H to 21h), even if the respective error event has not occurred. Manufacturer Specific error codes are not returned, when all error code data is requested.

All error types listed below must be supported (01H to 40H).

TANK LEVEL GAUGE ERROR CODE DATABASE **DB_Ad = TLG_DAT (01H) + TLG_ER_DAT (41H) + TLG_ER_ID (01H-40H)**				
Data_Id	***Data Element Name*** Description	Field Type (Value)	Read / Write in State	M/O
ERROR DATA				
1 (01H)	***TLG_Error_Type*** Every error has a unique error code. This number is the same number as used in the address *TLG_ER_ID* of this database. A list off all errors can be found in section 3.4.2. An unsolicited (without acknowledge) message is generated by the TLG when a major or minor error occurs.	bin8 (1-255)	R(1-3)	M
2 (02H)	***TLG_Err_Description*** Description of the error.	asc20	R(1-3) W(3)	O
3 (03H)	***TLG_Error_Total*** The total number of errors having that code. If more that 255 errors are counted, the value remains 255. When a 0 value is written in this *TLG_Error_Total*, the total is cleared and the date is recorded (see Data_Id 4 below).	bin8 (0-255)	R(1-3) W(3)	M
4 (04H)	***TLG_Error_Total_Erase_Date*** Date of the last *TLG_Error_Total* erase.	Date	R(1-3) W(3)	O1
UNSOLICITED DATA				
100 (64H)	***TLG_Error_Type_Mes*** The unsolicited (without acknowledge) error message *TLG_Error_Type_Mes* transmits only the data field *TLG_Error_Type* (description see Data_Id = 1).	bin8		M
MANUFACTURER / OIL COMPANY SPECIFIC				
200 to	Free to the manufacturer / oil company			

TANK LEVEL GAUGE ERROR CODE DATABASE DB_Ad = TLG_DAT (01H) + TLG_ER_DAT (41H) + TLG_ER_ID (01H-40H)				
Data_Id	***Data Element Name*** Description	Field Type (Value)	Read / Write in State	M/O
255				

3.4.2 TLG Errors

The errors have different priorities. In the following table the classification is done. For details in the behaviour of the TLG see chapter 2 (Tank Probe Behaviour Model).

Classification	ER_ID	Description
MAJOR ERROR	01H	RAM defect
	02H	ROM defect
	03H	Configuration or Parameter Error
	04H	Power supply out of order
	05H	Main Communication error
	06H-1FH	Spare
MINOR ERROR	20H	Battery error
	21H	Communication error
	22H-2FH	Spare
Manufacturer Specific	30H-40H	Spare

3.5 Tank Probe Data

3.5.1 Tank Probe Database

This data allows the CD to configure the individual TP's. The access to the tank probe is done by the database address TP_ID (tank probe identification). The TP_ID=20H is used to ask for all tank probes.

TANK PROBE DATABASE DB_Ad = TP_ID (21H-3FH)				
Data_Id	***Data Element Name*** Description	Field Type (Value)	Read / Write in State	M/O
CONFIGURATION				
1 (01H)	***TP_Manufacturer_Id*** To allow the CD to interrogate the manufacturer identity (as registered with the IFSF).	asc3	R(1-3)	M

TANK PROBE DATABASE DB_Ad = TP_ID (21H-3FH)				
Data_Id	***Data Element Name*** Description	Field Type (Value)	Read / Write in State	M/O
2 (02H)	***TP_Type*** This is a manufacturer specific Data_Id that specifies the type of probe that is installed. Please note that TP's that do not permit the *TP_Type* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *TP_Type* to the TP Type that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	asc3	R(1-3) W(3)	M
3 (03H)	***TP_Serial_Nb*** To allow the CD to interrogate the probe's serial number.	asc12	R(1-3) W(3)	M
4 (04H)	***TP_Model*** To allow the CD to interrogate the probe's model Please note that TP's that do not permit the *TP_Model* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *TP_Model* to the TP Model that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	asc3	R(1-3) W(3)	M
5 (05H)	***TP_Appl_Software_Ver*** To allow the CD to interrogate the version number of the application software of the TP. The *TP_Appl_Software_Ver* number format is '9999999999.99'.	asc12	R(1-3)	M
6 (06H)	***Prod_Nb*** The *Prod_Nb* is assigned by the CD during the system configuration and may be used to specify the type of product being measured by the TP. A write action for an address TP_ID with the *Prod_Nb* 00000000 means that the *Prod_Nb* must be deleted. The *Prod_Nb* is an oil company specific code to be used in reports. Please note that TP's that do not permit the *Prod_Nb* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Prod_Nb* to the Product Number that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	bcd8	R(1-3) W(3)	O
7 (07H)	***Prod_Description*** The *Prod_Description* is the description of the product measured by the TP. This description can be used by the TLG when reports are generated directly at the TLG.	asc16	R(1-3) W(3)	O

	Please note that TP's that do not permit the *Prod_Description* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Prod_Description* to the Product Description that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.			
8 (08H)	***Prod_Group_Code*** Specifies the product group for calculation of temperature corrected volume (G.S.V.) using a volume correction factor (V.C.F.) according ASTM or API. See ASTM D 1250 table 54 or API Std 2540 table 6 for more details. Please note that TP's that do not permit the *Prod_Group_Code* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Prod_Group_Code* to the Product Group Code that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	asc1	R(1-3) W(3)	O5
9 (09H)	***Ref_Density*** Specifies the reference density (in kilograms per cubic meter at reference temperature) of the product, used for calculating the volume correction factor (V.C.F.). See ASTM D 1250 table 54 or API Std 2540 table 6 for more details. Please note that TP's that do not permit the *Ref_Density* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Ref_Density* to the Reference Density that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	bin16	R(1-3) W(3)	O
10 (0AH)	***Tank_Diameter*** The diameter of the tank. Please note that TP's that do not permit the *Tank_Diameter* to be changed remotely should: - Reject any write attempts with a Data_ACK value of 2 (Read Only/Not Writable). - Must set the *Tank_Diameter* to the Tank Diameter that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Diameter	R(1-3) W(3)	O3
11 (0BH)	***Shell_Capacity*** The *Shell_Capacity* is used to specify the largest volume of product that a tank can hold. Please note that TP's that do not permit the *Shell_Capacity* to be changed remotely should: - Reject any write attempts with a Data_ACK value of 2 (Read	Long_ Volume	R(1-3) W(3)	O3

	Only/Not Writable). - Must set the *Shell_Capacity* to the Product Description that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.			
12 (0CH)	***Max_Safe_Fill_Capacity*** The *Max_Safe_Fill_Capacity* is used to specify the largest volume that the tank safely holds, taking temperature effects in to consideration. When the *Total_Observed_Volume* exceeds the *Max_Safe_Fill_Capacity* the tank is considered to be overfilled, and the Overfill Status is activated. Please note that TP's that do not permit the *Max_Safe_Fill_Capacity* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Max_Safe_Fill_Capacity* to the Maximum Safe Fill Capacity that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Long_ Volume	R(1-3) W(3)	O4
13 (0DH)	***Low_Capacity*** The *Low_Capacity* is used to specify the volume to which you can empty a tank without pumping vapour into the line. In other words, it is the amount of product that just reaches the entrance of the suction pipe. When the *Total_Observed_Volume* falls below the *Low_Capacity* the tank is considered to be underfilled, and the Underfill Status is activated. Please note that TP's that do not permit the *Low_Capacity* to be changed remotely should: - Reject any write attempts with a Data_ACK value of 2 (Read Only/Not Writable). - Must set the *Low_Capacity* to the Low Capacity limit that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Long_ Volume	R(1-3) W(3)	O4
14 (0EH)	***Min_Operating_Capacity*** The *Min_Operating_Capacity* is used to specify the minimum capacity that allows the petrol station to operate while waiting for a delivery of product. When the *Total_Observed_Volume* falls below the *Min_Operating_Capacity* a delivery should be requested and the Supply Warning is activated. Please note that TP's that do not permit the *Min_Operating_Capacity* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Min_Operating_Capacity* to the Minimum Operating Capacity limit that is hard coded in their program. When a master reset / coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Long_ Volume	R(1-3) W(3)	O4
15 (0FH)	***HiHi_Level_Setpoint*** The *HiHi_Level_Setpoint* is used to specify the level of the 'high-	Level	R(1-3) W(3)	O2

	high level alarm'. This alarm is activated when the product level is higher than the *HiHi_Level_Setpoint*. Please note that TP's that do not permit the *HiHi_Level_Setpoint* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *HiHi_Level_Setpoint* to the High High Level Setpoint limit that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.			
16 (10H)	***Hi_Level_Setpoint*** The *Hi_Level_Setpoint* is used to specify the level of the 'high level alarm'. This alarm is activated when the product level is higher than the *Hi_Level_Setpoint*. Please note that TP's that do not permit the *Hi_Level_Setpoint* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Hi_Level_Setpoint* to the High Level Setpoint limit that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Level	R(1-3) W(3)	O2
17 (11H)	***Lo_Level_Setpoint*** The *Lo_Level_Setpoint* is used to specify the level of the 'low product alarm'. This alarm is activated when the product level is lower than the *Lo_Level_Setpoint*. Please note that TP's that do not permit the *Lo_Level_Setpoint* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *Lo_Level_Setpoint* to the Low Level Setpoint limit that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Level	R(1-3) W(3)	O2
18 (12H)	***LoLo_Level_Setpoint*** The *LoLo_Level_Setpoint* is used to specify the level of the 'low-low product alarm'. This alarm is activated when the product level is lower than the *LoLo_Level_Setpoint*. Please note that TP's that do not permit the *LoLo_Level_Setpoint* to be changed remotely should: - Reject any write attempts with a *Data_ACK* value of 2 (Read Only/Not Writable). - Must set the *LoLo_Level_Setpoint* to the Low Low Level Setpoint limit that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Level	R(1-3) W(3)	O2
19 (13H)	***Hi_Water_Setpoint*** The *Hi_Water_Setpoint* is used to specify the level of the 'high water alarm'. This alarm is activated when the water level is higher than the *Hi_Water_Setpoint*. Please note that TP's that do not permit the *Hi_Water_Setpoint* to	Level	R(1-3) W(3)	O2

	be changed remotely should: - Reject any write attempts with a Data_ACK value of 2 (Read Only/Not Writable). - Must set the *Hi_Water_Setpoint* to the High Water Setpoint limit that is hard coded in their program. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.			
20 (14H)	***Water_Detection_Thresh*** The *Water_Detection_Thresh* is used to specify the minimum level at which the TP can detect water. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Level	R(1-3)	O2
21 (15H)	***Tank_Tilt_Offset*** The *Tank_Tilt_Offset* is used to specify the height offset that should be added to the measured fuel and water heights to account for the fact that the gauge is not installed in the centre of the tank. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Level	R(1-3) W(3)	O
22 (16H)	***Tank_Manifold_Partners*** The *Tank_Manifold_Partners* is used to specify the tank numbers of all other tanks (up to a maximum of eight) to which this one is connected through siphon manifolds. A value of zero in any bcd byte indicates no further manifolding exists, eg: 00, 00, 00, 00, 00, 00, 00, 00 - this tank is not manifolded. 02, 03, 05, 00, 00, 00, 00, 00 - this tank is manifolded to tanks 2, 3 and 5. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to its default value.	Bcd16	R(1-3) W(3)	O
23 (17H)	***TP_Measurement_Units*** The *TP_Measurement_Units* specifies the units in which all data will be reported: 0 – metric 1 - US units 2 - imperial units Please note that TP's that do not support the *TP_Measurement_Units* should report everything in metric units. When a master reset/coldstart occurs on the TP device the TP should reset this Data_Id to metric.	bin8	R(1-3) W(3)	O
CONTROL DATA				
26 (1AH)	***TP_Config_Lock*** Used to lock the communications of a Tank Probe to one controlling device while the Tank Probe is being configured. X,Y = Controller Device that locked the Tank Probe (X = Subnet, Y = Node) If the controlling device fails after being locked, a time out is applied. See section 5.3 Handling of Config_Lock Config_Lock is at TP level, therefore all TP's'must be in	Bin 16	R(3) W(3)	O

	Maintenance before the comms is locked. MS_ACK 9 (configuration lock error) is sent in responses to other devices attempting to communicate with the Tank Probe during configuration.			
32 (20H)	***TP_Status*** Used to indicate the state of the TP. Please see the Tank Probe State Diagram for details of the individual states (Chapter 2.1 of this document). An unsolicited (without acknowledge) message is generated by the TP for each change in the *TP_Status* state.	bin8 (1-3)	R(1-3)	M
33 (21H)	***TP_Alarm*** Used to indicate the state of the alarm status's for a tank. bit 1 set = Tank Probe error bit 2 set = Overfill status bit 3 set = Underfill status bit 4 set = Supply warning bit 5 set = High-High level alarm bit 6 set = High level alarm bit 7 set = Low level alarm bit 8 set = Low-Low level alarm bit 9 set = High water alarm bit 10 set = Tank loss alarm bit 11 set = Tank leak alarm bit 12 set = not used bit 13 set = not used bit 14 set = not used bit 15 set = not used bit 16 set = not used An unsolicited (without acknowledge) message is generated by the TP for each change in the *TP_Alarm*.	bin16 (0- 65535)	R(1-3)	M
TANK READING				
64 (40H)	***Product_Level*** Specifies the level of the product.	Level	R(2)	M
65 (41H)	***Total_Observed_Volume*** Specifies the volume of product, including free water, in the tank.	Long_ Volume	R(2)	O3
66 (42H)	***Gross_Standard_Volume*** Specifies the volume, excluding the free water in the tank, corrected to the reference temperature.	Long_ Volume	R(2)	O5
67 (43H)	***Average_Temp*** Specifies the average temperature of the product. This Data_Id must be supported if the TP is capable of determining the temperature.	Temp	R(2)	O5
68 (44H)	***Water_Level*** Specifies the water level in the tank.	Level	R(2)	M
69 (45H)	***Observed_Density*** Specifies the average density (in kilograms per cubic meter) of the product. This Data_Id must be supported if the TP is capable of determining the density of the product.	bin16 (0- 65535)	R(2)	O

70 (46H)	***Last_Reading_Date*** Specifies the date of the last measurement update (level, volume etc.)	DATE	R(2)	O1
71 (47H)	***Last_Reading_Time*** Specifies the date of the last measurement update (level, volume etc.)	TIME	R(2)	O1
UNSOLICITED				
100 (64H)	***TP_Status_Message*** A *TP_Status_Message* is sent unsolicited (without acknowledge) by the TP whenever a change occurs in the *TP_Status* or *TP_Alarm* or whenever the state cannot be changed following request by the CD to change state. The TP_Status_Message includes: - *TP_Status* (Data_Id = 32) - *TP_Alarm* (Data_Id = 33)	bin8, bin16		M
MANUFACTURER / OIL COMPANY SPECIFIC				
200 to 255	Free to the manufacturer / oil company			

3.5.2 Tank Contents Table

This data allows a CD to specify the tank contents table for a given TP.

TANK CONTENTS TABLE DATABASE DB_Ad = TP_ID (21H-3FH) + CAL_DAT (21H) + ENTRY (01H-FFH)				
Data_Id	***Data Element Name*** Description	Field Type (Value)	Read / Write in State	M/O
CONFIGURATION				
1 (01H)	***Strap_Level*** Specifies the strap level height.	Level	R(1-3) W(3)	O
2 (02H)	***Strap_Vol*** Specifies the volume of product stored in the tank when the height reading is equal to the given height of Data_Id 1 above.	Long_ Volume	R(1-3) W(3)	O
MANUFACTURER / OIL COMPANY SPECIFIC				
200 to 255	Free to the manufacturer / oil company			

3.5.3 Tank Temperature Table

This data allows a CD to interrogate the tank temperature table for a given TP.

TANK TEMPERATURE TABLE DATABASE DB_Ad = TP_ID (21H-3FH) + TEMP_DAT (22H) + TEMP_ADDR (01H-08H)				
Data_Id	***Data Element Name*** Description	Field Type (Value)	Read / Write in State	M/O
CONFIGURATION				
1 (01H)	***Temp_height*** Specifies the height of the temperature sensor from the bottom of the tank. To determine how many sensors exist, the CD should ask for all 8 allowable sensors; the TP will respond with a *Data_Ack* value of 4 (data does not exist in this device) for any that are not supported.	LEVEL	R(1-3)	O5
2 (02H)	***Temp_value*** Specifies the temperature measured by the sensor. To determine how many sensors exist, the CD should ask for all 8 allowable sensors; the TP will respond with a *Data_Ack* value of 4 (data does not exist in this device) for any that are not supported.	LONG_ TEMP	R(1-3)	O5
MANUFACTURER / OIL COMPANY SPECIFIC				
200 to 255	Free to the manufacturer / oil company			

3.6 Tank Probe Error Code Data

3.6.1 TP Error Code Database

This data allows the CD to handle the error data from a TP.

The TP_ER_DAT = 40H is used to ask for all error code data. Please note that the TP returns all defined error codes in the below list (01H to 05H and 20H to 21H), even if the respective error event has not occurred. Manufacturer Specific error codes are not returned, when all error code data is requested.

All error types listed below must be supported (01H to 40H).

ERROR CODE DATABASE DB_Ad = TP_ID (21H-3FH) + TP_ER_DAT (41H) + TP_ER_ID (01H-40H)				
Data_Id	***Data Element Name*** Description	Field Type (Value)	Read / Write in State	M/O
ERROR DATA				
1 (01H)	***TP_Error_Type*** Every error has a unique error code. This number is the same	bin8 (1-255)	R(1-3)	M

ERROR CODE DATABASE DB_Ad = TP_ID (21H-3FH) + TP_ER_DAT (41H) + TP_ER_ID (01H-40H)				
Data_Id	***Data Element Name*** Description	Field Type (Value)	Read / Write in State	M/O
	number as used in the address *TP_ER_ID* of this database. A list off all errors is at the end of this table. An unsolicited (without acknowledge) *TP_Error_Type_Mes* is generated by the TP when a major or minor error occurs. An unsolicited (without acknowledge) data *TP_Status_Message* is generated when a major error causes a state change.			
2 (02H)	***TP_Err_Description*** Description of the error.	asc20	R(1-3) W(3)	O
3 (03H)	***TP_Error_Total*** Total of error having that code. If more that 255 errors are counted, the value remains 255. When a 0 value is written in this *TP_Error_Total*, the total is cleared and the date is recorded (see Data_Id 4 below).	bin8 (0-255)	R(1-3) W(3)	M
4 (04H)	***TP_Error_Total_Erase_Date*** Date of the last total erase.	Date	R(1-3) W(3)	O1
5 (05H)	***TP_Error_Status*** Indicates the device status at the time the error occurred.	bin8	R(1-3)	M
UNSOLICITED DATA				
100 (64H)	***TP_Error_Type_Mes*** The unsolicited (without acknowledge) error message *TP_Error_Type_Mes* transmits only the data field *TP_Error_Type* (description see Data_Id = 1).	bin8		M
MANUFACTURER / OIL COMPANY SPECIFIC				
200 to 255	Free to the manufacturer / oil company			

3.6.2 TP Errors

The errors have different priorities. In the following table the classification is done. For details in the behaviour of the TP see chapter 2 (Tank Probe Behaviour Model).

Classification	ER_ID	Description
MAJOR ERROR	01H	RAM defect
	02H	ROM defect
	03H	Configuration or Parameter Error
	04H	Power supply out of order
	05H	Main Communication error

Classification	ER_ID	Description
	06H-1FH	Spare
MINOR ERROR	20H	Battery error
	21H	Communication error
	22H-2FH	Spare
Manufacturer Specific	30H-40H	Spare

4 Tank Gauging Terms & Definitions

The field of tank gauging has, like all disciplines, it's own terminology and jargon. Some terms are standards, and are described in documents by the American Petroleum Institute (API), the British Institute of Petroleum (IP), the International Organisation for Standardisation (ISO) and the International Organisation for Legal Metrology (OIML). It is important in the IFSF standardisation effort to use these terms and definitions. This will prevent confusion during the implementation of the communication standard by the different tank gauge manufacturers.

In this chapter we would like to introduce some of these standard terms and definitions as some are mentioned in the IFSF Tank Gauge Application Protocol. We recognise that some manufacturers might use different terms, but we propose to use as much standard terms as possible.

4.1 General Definitions

The below definitions describe the different capacities and volumes of a tank. Those marked with (*) are not used on petrol stations, but are included to paint the complete picture.

Shell Capacity — The largest volume of product that a tank can hold.

Maximum Safe Fill Capacity — The largest volume that the tank safely holds, taking temperature effects in to consideration

Low Capacity — This is the volume to which you can empty a tank without pumping vapour into the line. In other words, it is the amount of product that just reaches the entrance of the suction pipe.

Working Capacity — The liquid quantity that can safely be pumped in and out of the tank without running the risk of overfilling or drawing out of the tank below the high suction point. (*Working Cap = Max Safe Fill Cap - Low Cap*)

Available Volume — The liquid quantity that can safely be pumped out of the tank without running the risk of drawing product out of the tank below the high suction point.

Available Room — The liquid quantity that can safely be pumped in the tank without running the risk of overfilling.

Total Observed Volume (T.O.V.) — The volume of product including entrained Sediment & Water and Free Water in the tank.

Product Level — Distance between the surface of the liquid and the gauge reference point.

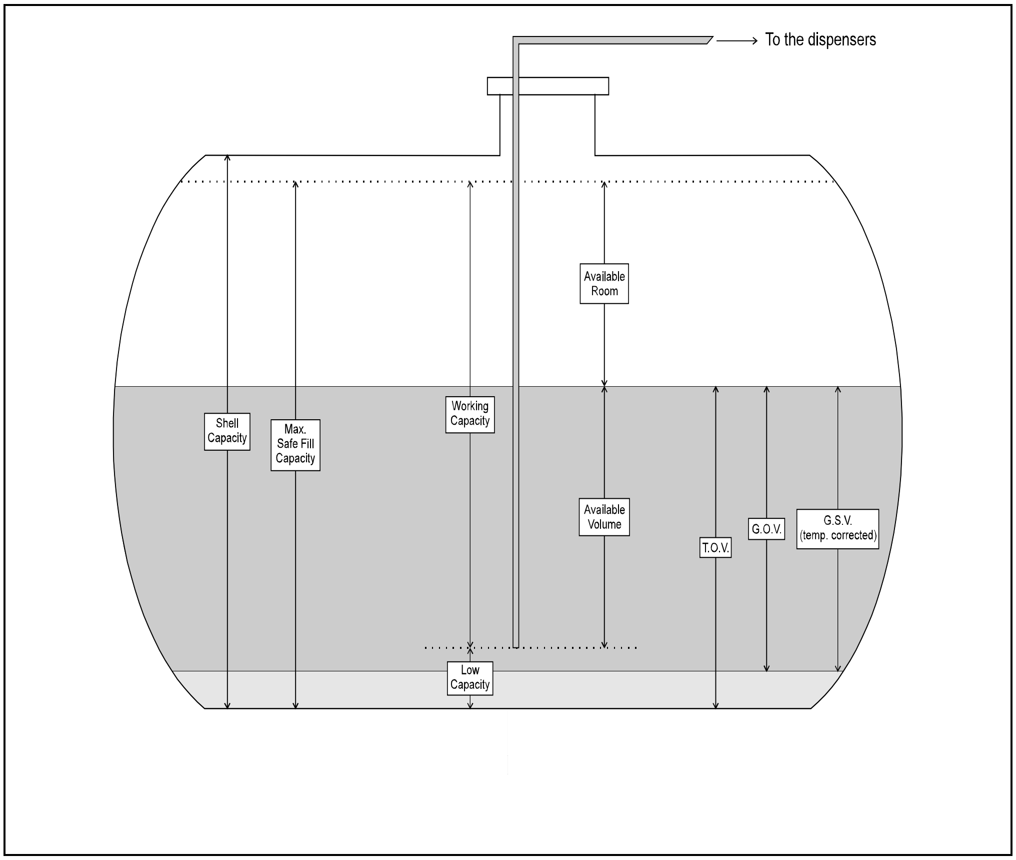


Figure 6 : Tanks

Gross Observed Volume (G.O.V.)(*) — The Total Observed Volume (at observed temperature) corrected for the volume of free water at the bottom of the tank. (*G.O.V. = T.O.V. - F.W.V.)*

Gross Standard Volume (G.S.V.) — The Gross Observed Volume (at observed temperature) corrected to the reference temperature. This calculation involves the Volume Correction Factor (VCF) which varies from product to product and depends on the product type (crude, diesel, LPG etc.), the product temperature and the product density. (*G.S.V. = G.O.V. x VCF)*

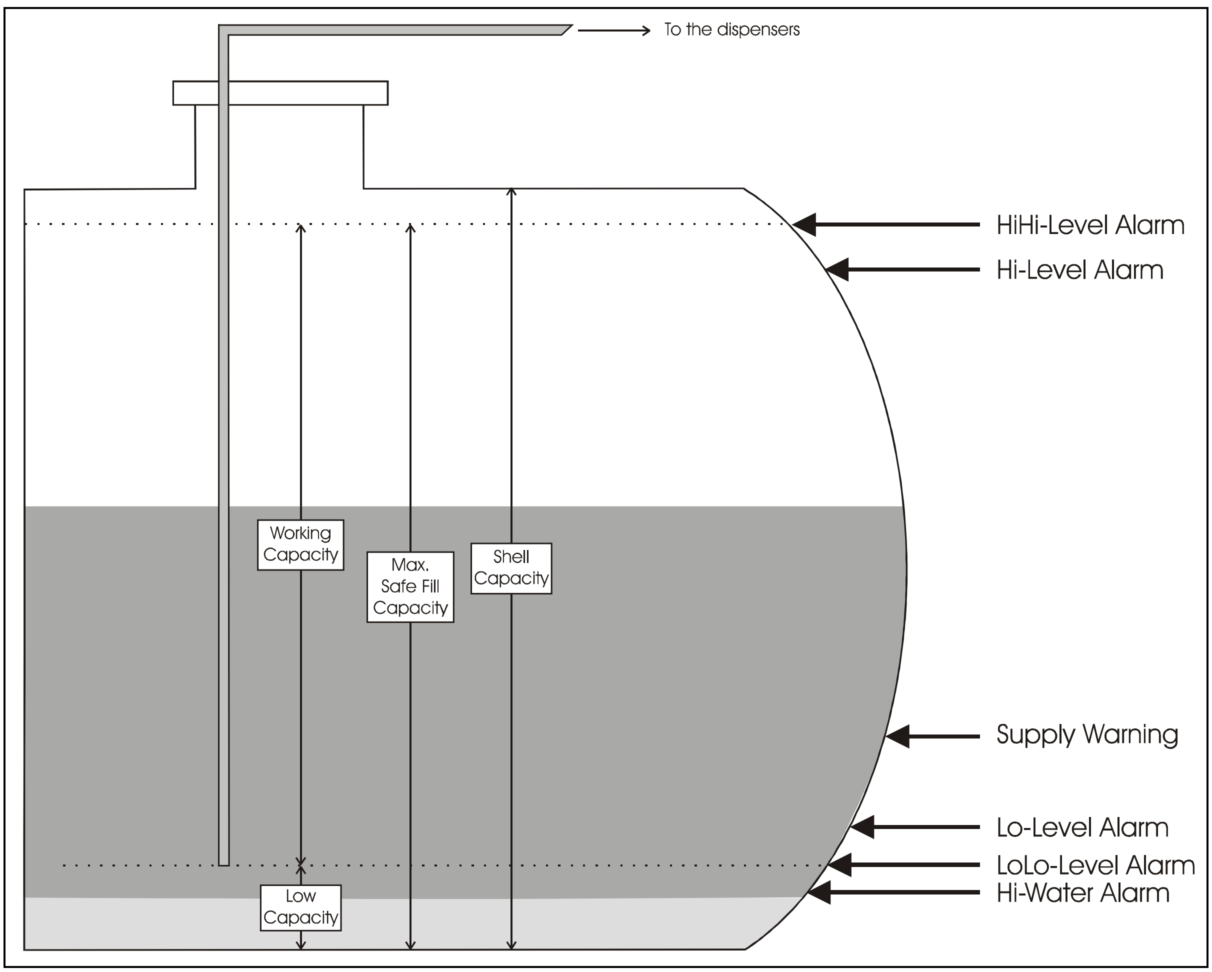
Sediment & Water (S&W)(*) — The volume of entrained sediment and water in the product. Generally stated as a percentage for the combination.

Net Standard Volume (N.S.V.)(*) — The Gross Standard Volume, corrected for the volume of sediment and water suspended in the product at reference temperature and reference pressure.

Total Gross Standard Volume (T.G.S.V.)(*)	The Gross Standard Volume, combined with the volume of product in vapour. The liquid volume in the vapour room is the quantity in gaseous form above the product. When the tank fills, the vapour condenses partially and changes back to liquid. (*T.G.S.V. = G.S.V. + Liquid Volume in Vapour Space)*
Free Water Level (F.W.L.)	The level of free water at the base of the tank. Generally measured with a water detecting paste, which changes colour when exposed to water.
Free Water Volume (F.W.V.)(*)	The volume of free water at the base of the tank, used in calculating the G.O.V. The free water volume is calculated through the free water level and the tank capacity table.

4.2 Definition of Alarms

Below the general definitions of the level alarms used in the field of tank gauging. The standardisation documents do not mention alarms, and the terms HiHi, Hi, Lo and LoLo have developed from general usage into a de-facto standard.



HiHi-Level Alarm	The highest product level that should never be exceeded for safety purposes. When the HiHi-Level alarm is active there is an *emergency* situation.
Hi-Level Alarm	When the Hi-level alarm is active, it indicates that the filling of the tank needs to be stopped. The value of the Hi-level alarm is always lower than that of the HiHi-Level alarm, but higher than that of the Lo-Level alarm.
Lo-Level Alarm	When the Lo-level alarm is active, it indicates the pumping of product from the tank needs to be stopped. The value of the Lo-level alarm is always higher than that of the LoLo-Level alarm, but lower than that of the Hi-Level alarm.
LoLo-Level Alarm	The lowest product level which should never be exceeded for safety purposes. When the LoLo-Level alarm is active there is an *emergency* situation.
Hi-Water Alarm	The highest water level that is allowable for operational purposes. When the water level exceeds the Hi-Water value, there is an increasing risk of the pumps sucking water into the line.

5 Implementation Guidelines & Recommendations

This section gives guidelines & recommendation for implementations of the IFSF Tank Application Protocol.

5.1 Handling after a Device Master Reset/Cold Start or Initial Start-up

After a master reset, cold start, initial start-up or discovery that the device's configuration is corrupted, the Tank Level Gauge should:

- Initialise the Communication Specification's Heartbeat_Interval to 10 seconds.
- Start generating Heartbeat messages with a Device_Status indicating that configuration is required.
- Reset the Communication Specification's Recipient Address Table.
- Where a default value exists for a Data_Id, the Tank Level Gauge should set up the Data_Id's value accordingly.

5.2 Handling after a Reset or Power Off

After a master reset of the Tank Level Gauge the device should:

- Check that device configuration is valid. If the configuration is corrupt, please treat the condition as described for master reset/cold start (see above).
- **Do not** clear the Communication Specification's Recipient Address Table.
- **Do not** reset Data_Id's to their default values.

5.3 Handling of Config_Lock

A new assignment can only be received by a Tank Probe after a reset (not assigned, i.e. 0,0 is written) by the device that previously assigned the Tank Probe.

In cases, where the CD that assigned the Tank Probe has 'crashed' and is off-line the assignment can be cleared by another CD. This is achieved by setting the *Config_Lock* to the same as the Tank Level Gauge's own application Subnet & Node.
The Tank Level Gauge then resets the *Config_Lock* to 0,0.
This method of clearing can also be used by the assigning CD.

Unlocking.

a. *Config_Lock* equals 0000 (not locked):
   - Any CD can set the *Config_Lock* out of 0000.

b. *Config_Lock* does not equal 0000 (locked to a particular CD):
   - The CD which owns the lock writes 0000 to *Config_Lock*. Accepted. Normal unlock.
   - The CD which owns the lock writes Tank Level Gauge's own SN address to *Config_Lock*. Accepted. Peculiar emergency unlock (the CD can use Normal unlock).
   - The CD which does NOT own the lock writes 0000 to *Config_Lock*. Rejected with NAK (Data_Ack of 2). Incorrect normal unlock.
   - The CD which owns the lock is off-line: Any other CD (CD does not need to be in RAT) writes the Tank Level Gauges's SN address into the *Config_Lock*. Accepted. Emergency unlock.
   - The CD which owns the lock is on-line: Any other CD writes the Tank Level Gauge's own SN address into the *Config_Lock*. Rejected with NAK (Data_Ack of 2). Incorrect emergency unlock.

Note 1: The Tank Level Gauge has to monitor the heartbeats from the CD(s) owning the lock(s) independently of the RAT (otherwise, lock "stealing" would be possible).

5.4 Handling after power down

Config_Lock should be volatile. This will determine what happens to this data element after a power down.