Design Specification for

AFT Sensor

Approvals

Customer: _____

Name: _____

Title: _____

Date: _____

Veethree: _____

Name: _____

Title: _____

Date: _____

Facility: Indication Instruments Limited
Plot No.19, Sector-6, Faridabad
Haryana, India
Rev# 0.0
Last update: May 31, 2022

TABLE OF CONTENTS

TABLES & FIGURES

No table of figures entries found.

REVISION HISTORY

Rev	Date	Author	Reviewed By	Description
0.0	31st May 2022	Ruchi Bhargava	Nikita/Anuj Garg	Initial version

1. Introduction

This document details the idea of Fuel Anti-Theft Sensor (AFT) or capacitive sensor. The proposed method of measurement of fuel level is based on the variation in the capacitance based on the difference in dielectric properties between fuel and free air without any moving parts. The details of implementation are outside the scope of this document.

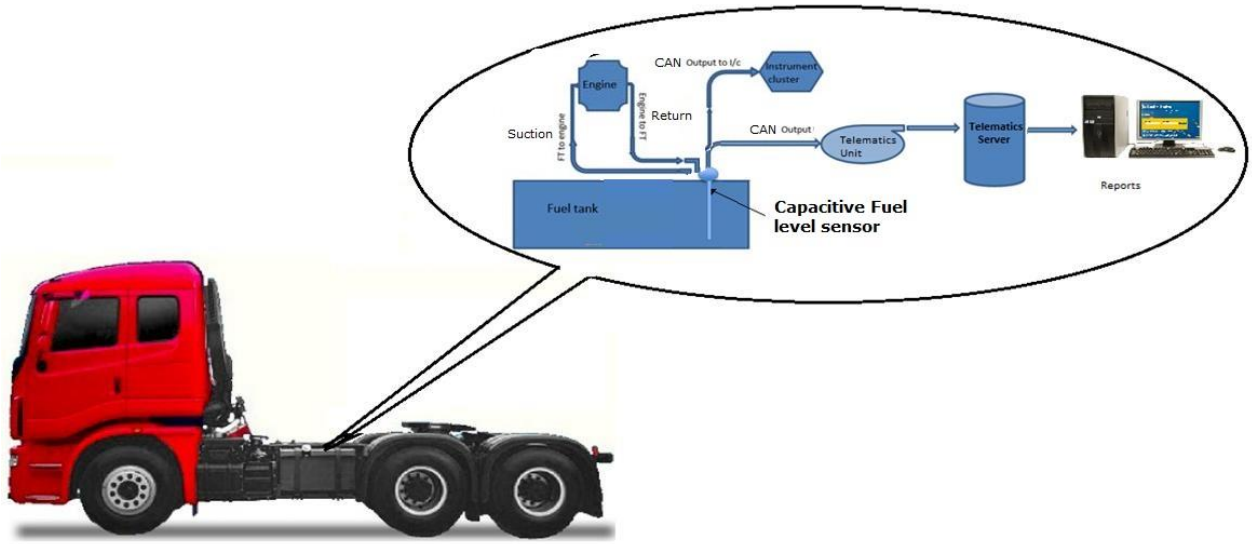
2. Acronyms, Abbreviations and Definitions

AFT	Anti Fuel Theft Sensor

3. References

Reference	Document
Emails exchanged with TML	

4. System Architecture



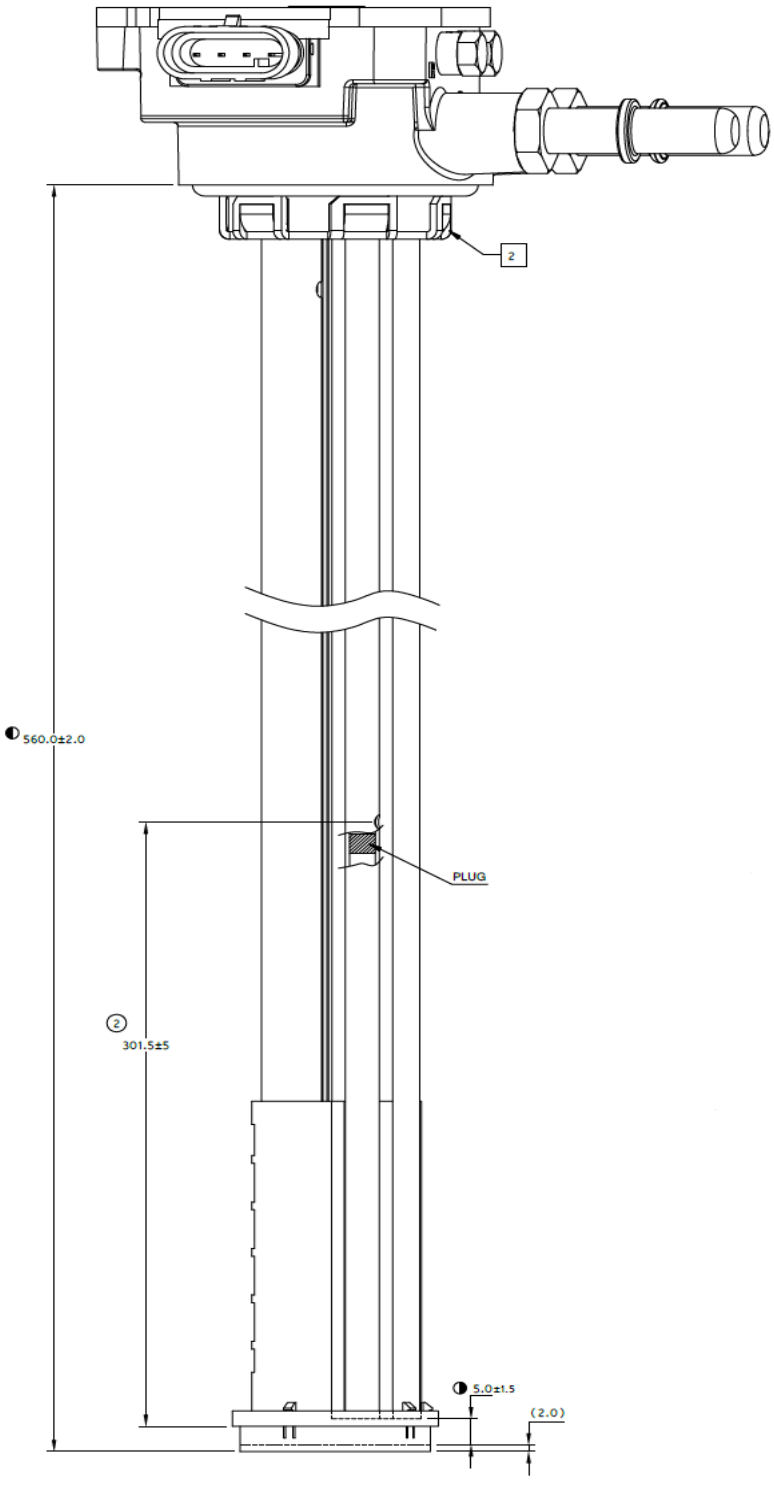
MCU Platform : Renesas

Memory :

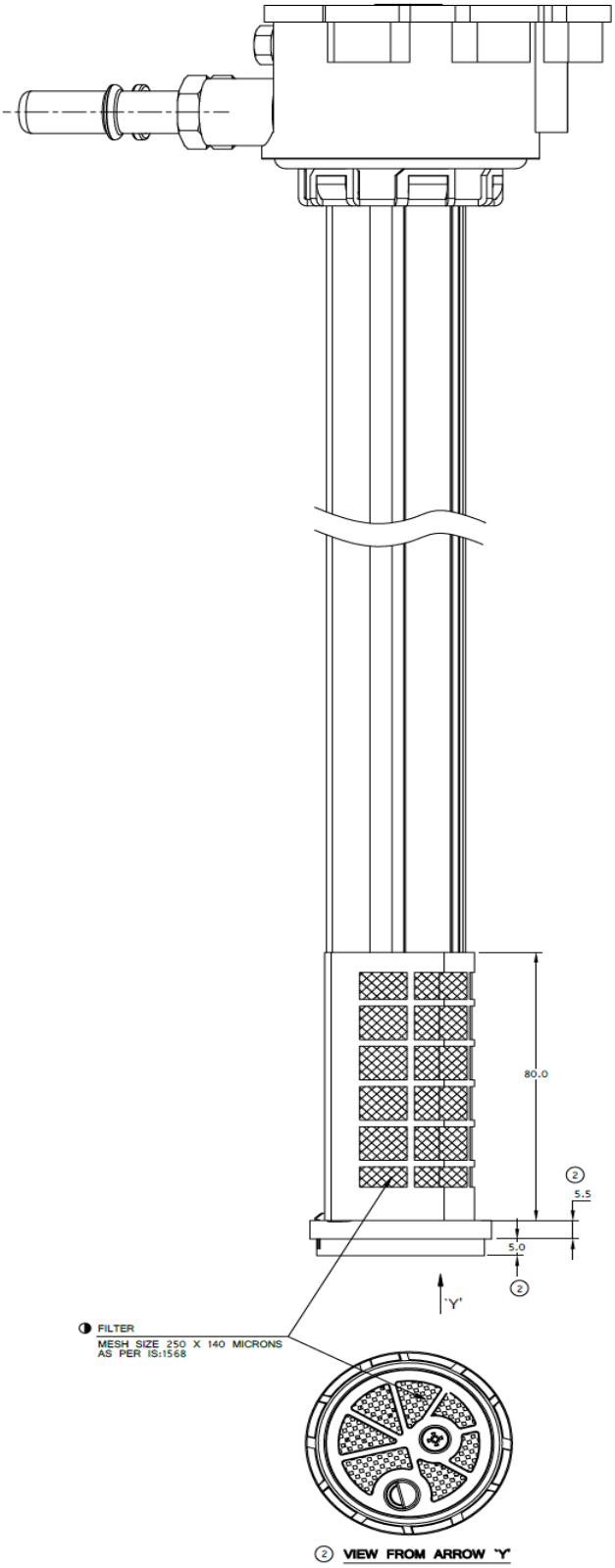
5. Fitment Requirement

Variant 1 : 365 Ltr.

View From Arrow X



View From Arrow Y



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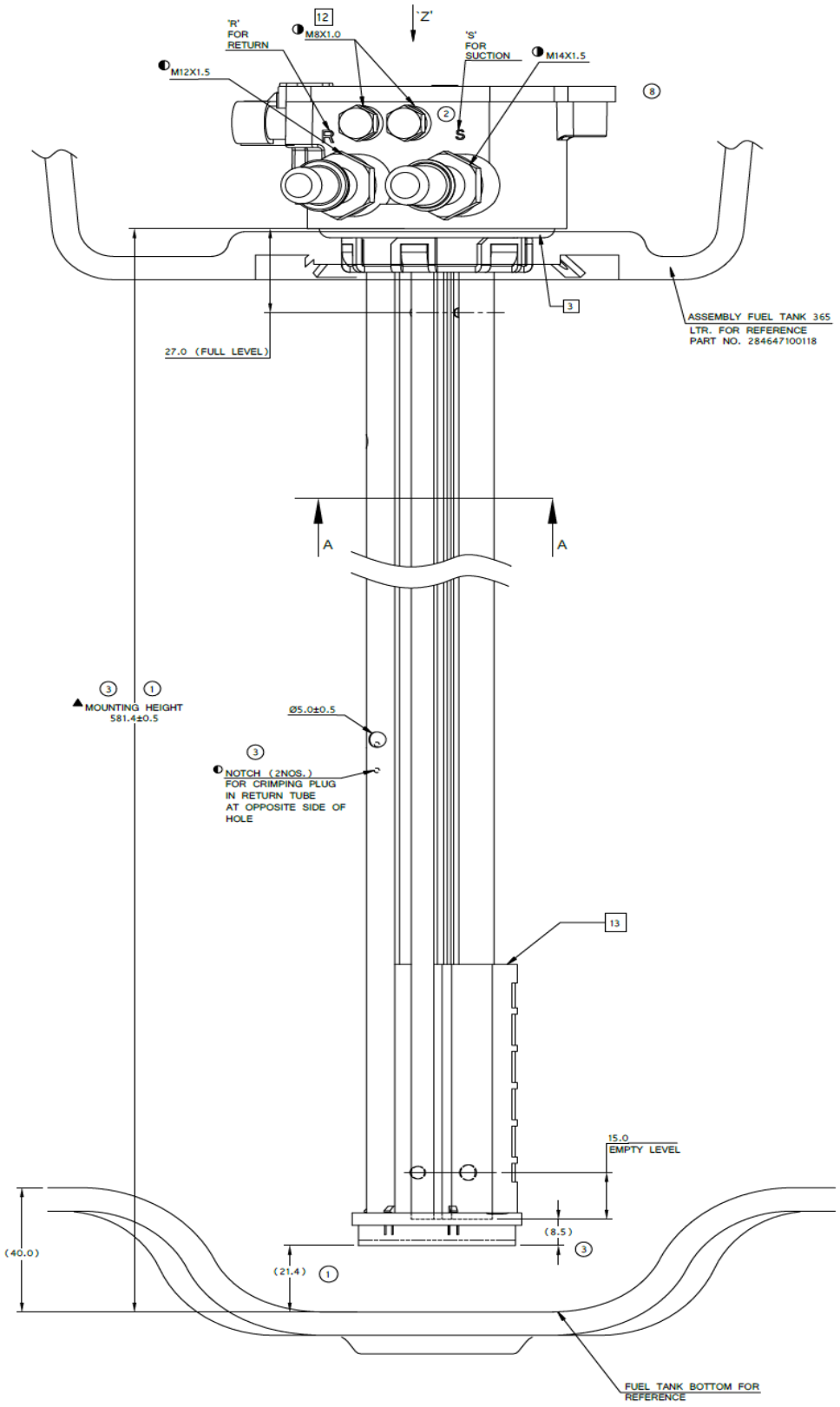
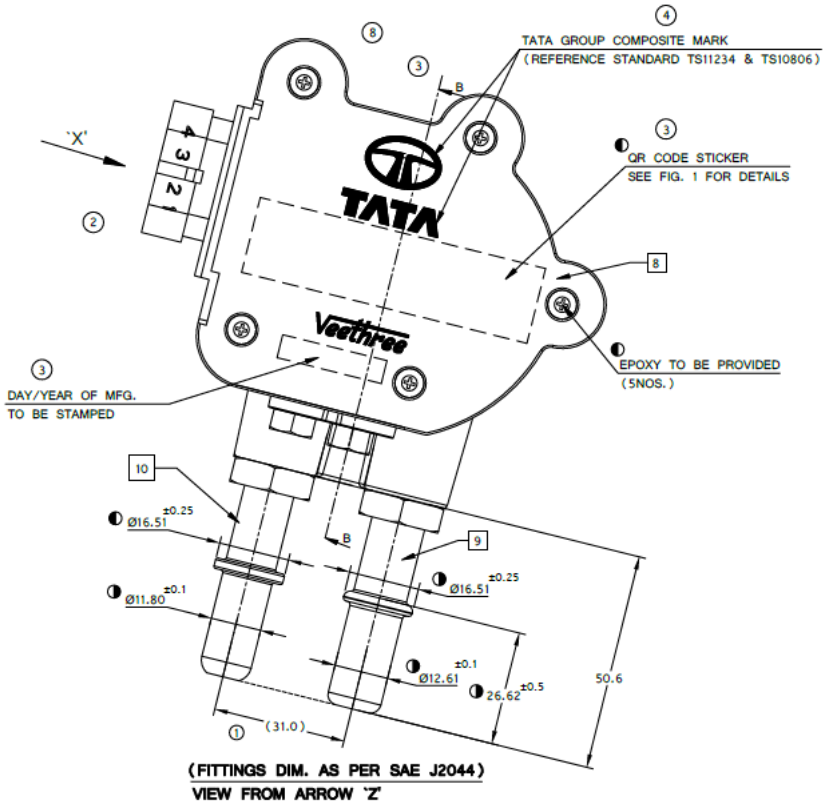
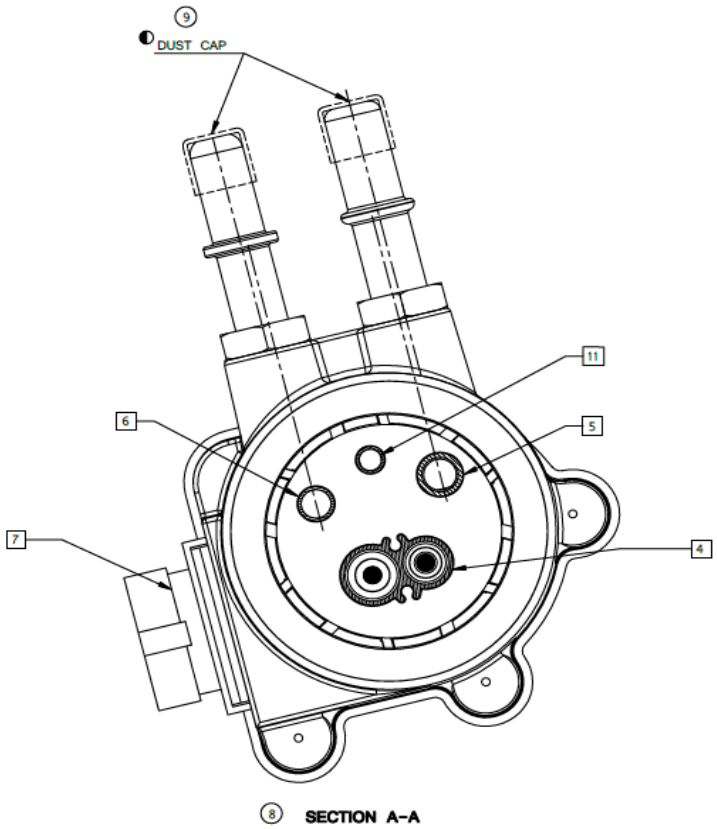
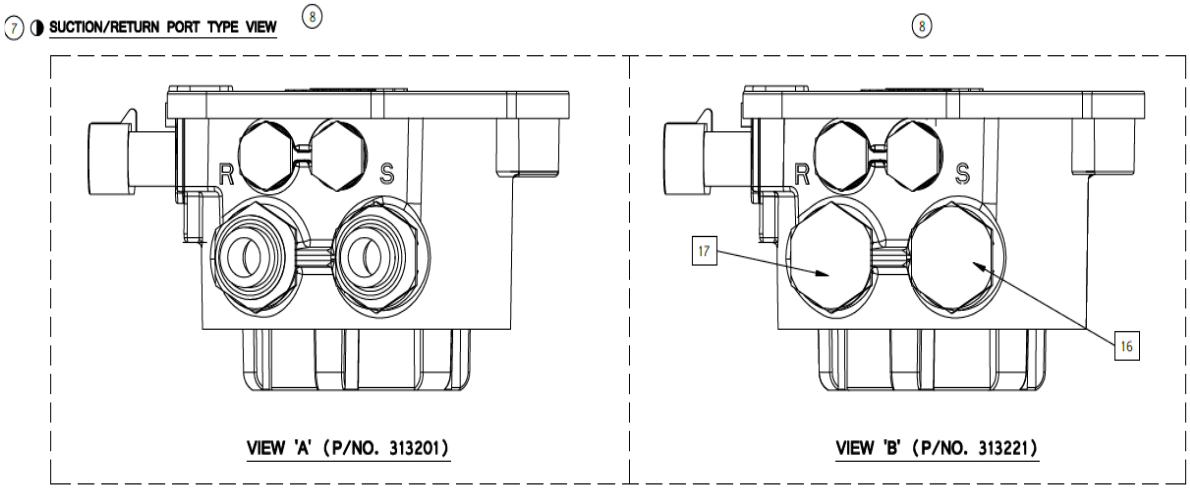




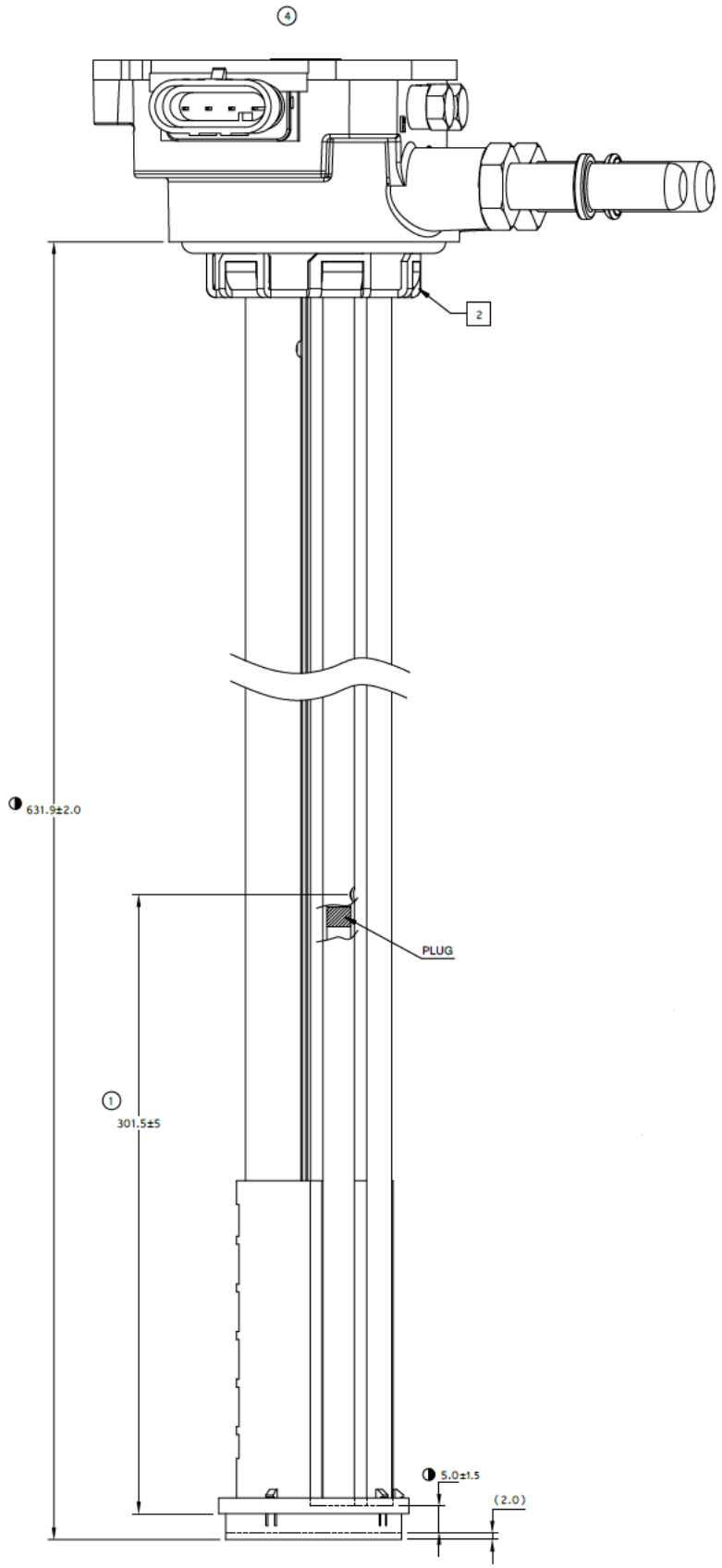


Suction/Return Port Type View



Variant 2 : 300 Ltr. & 280 Ltr.

View From Arrow X



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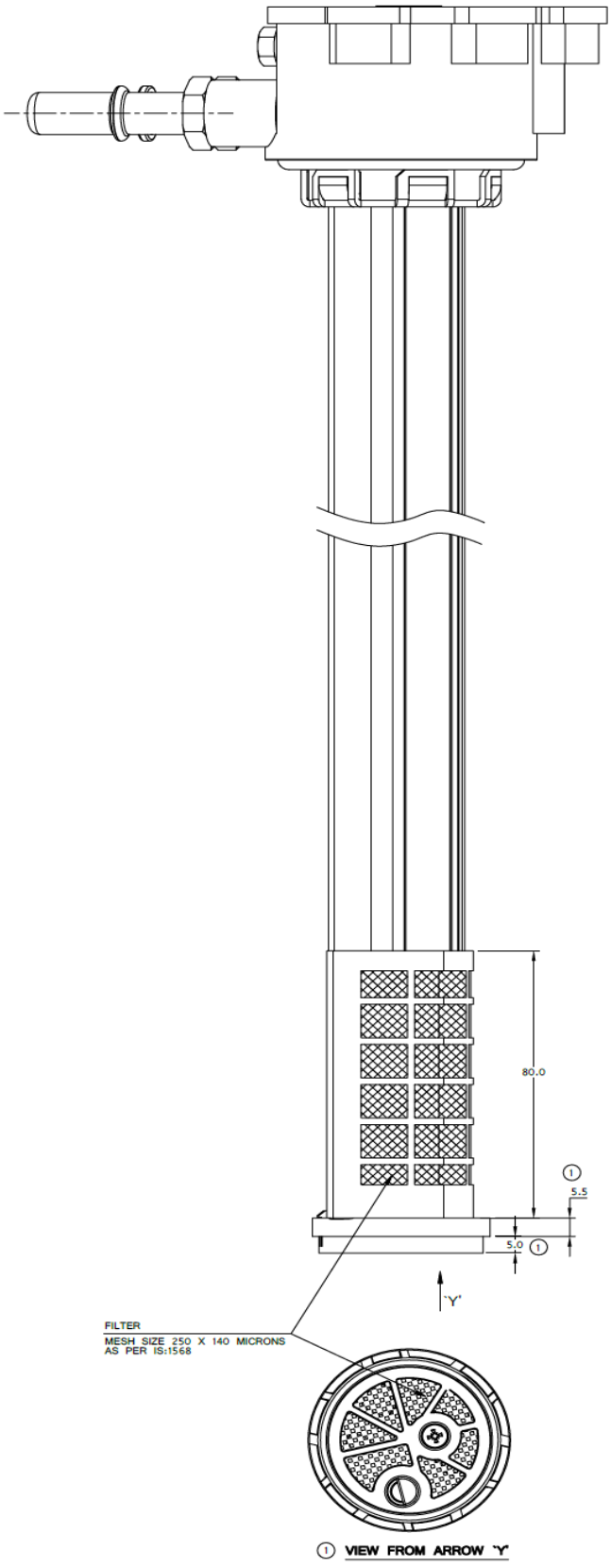

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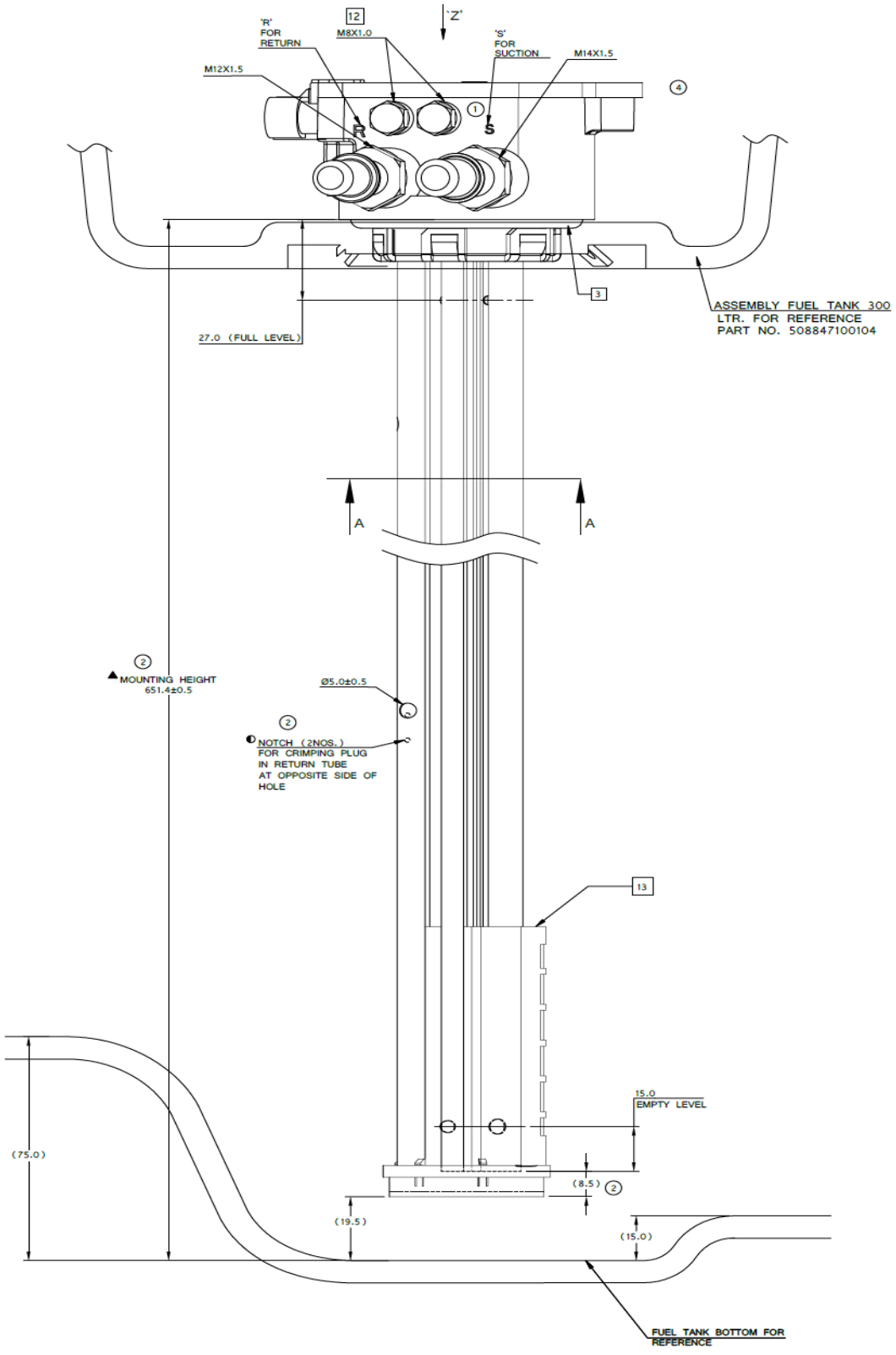
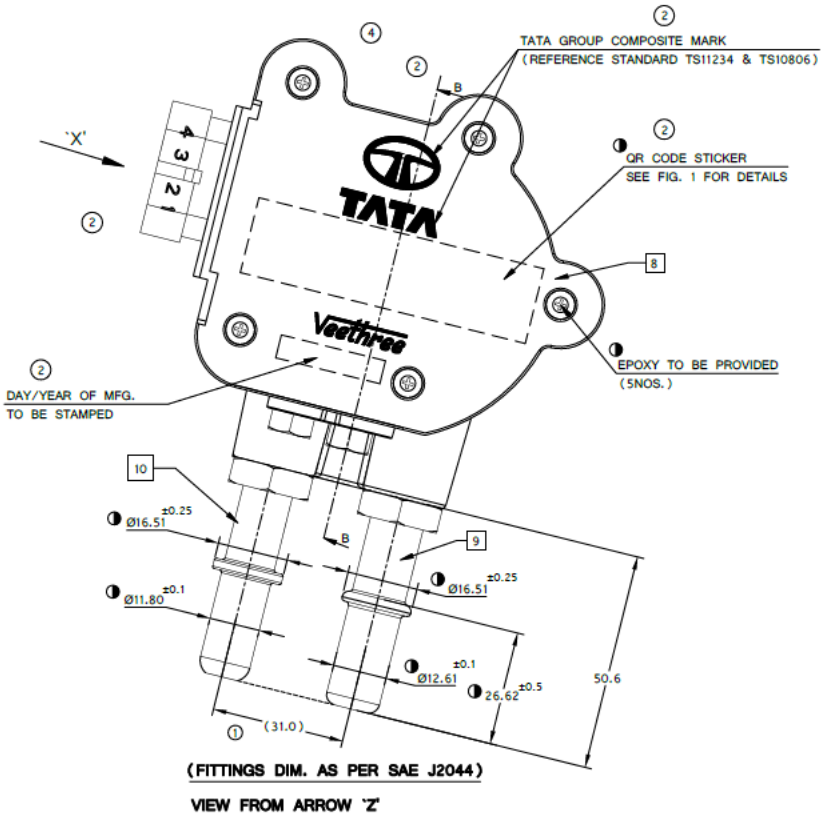
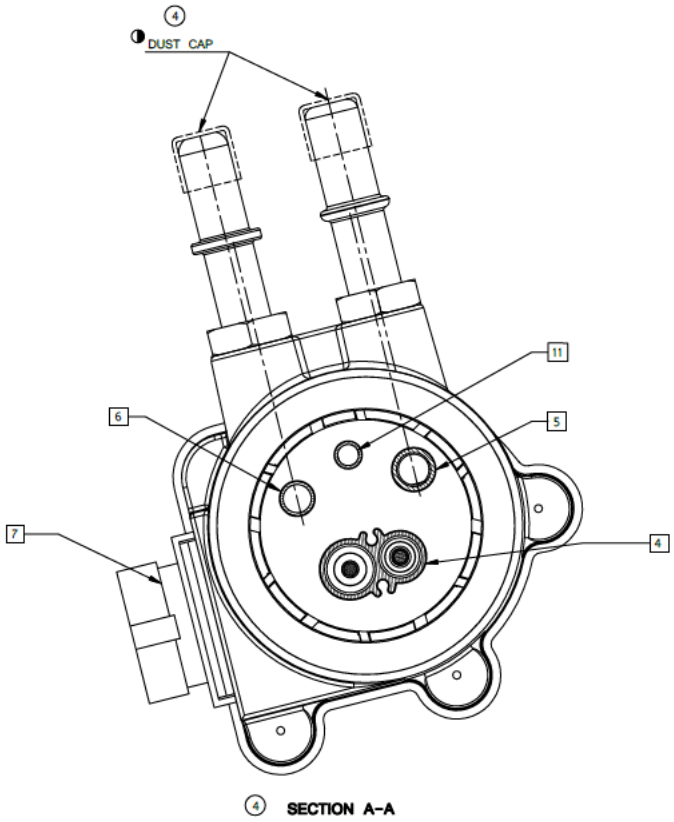
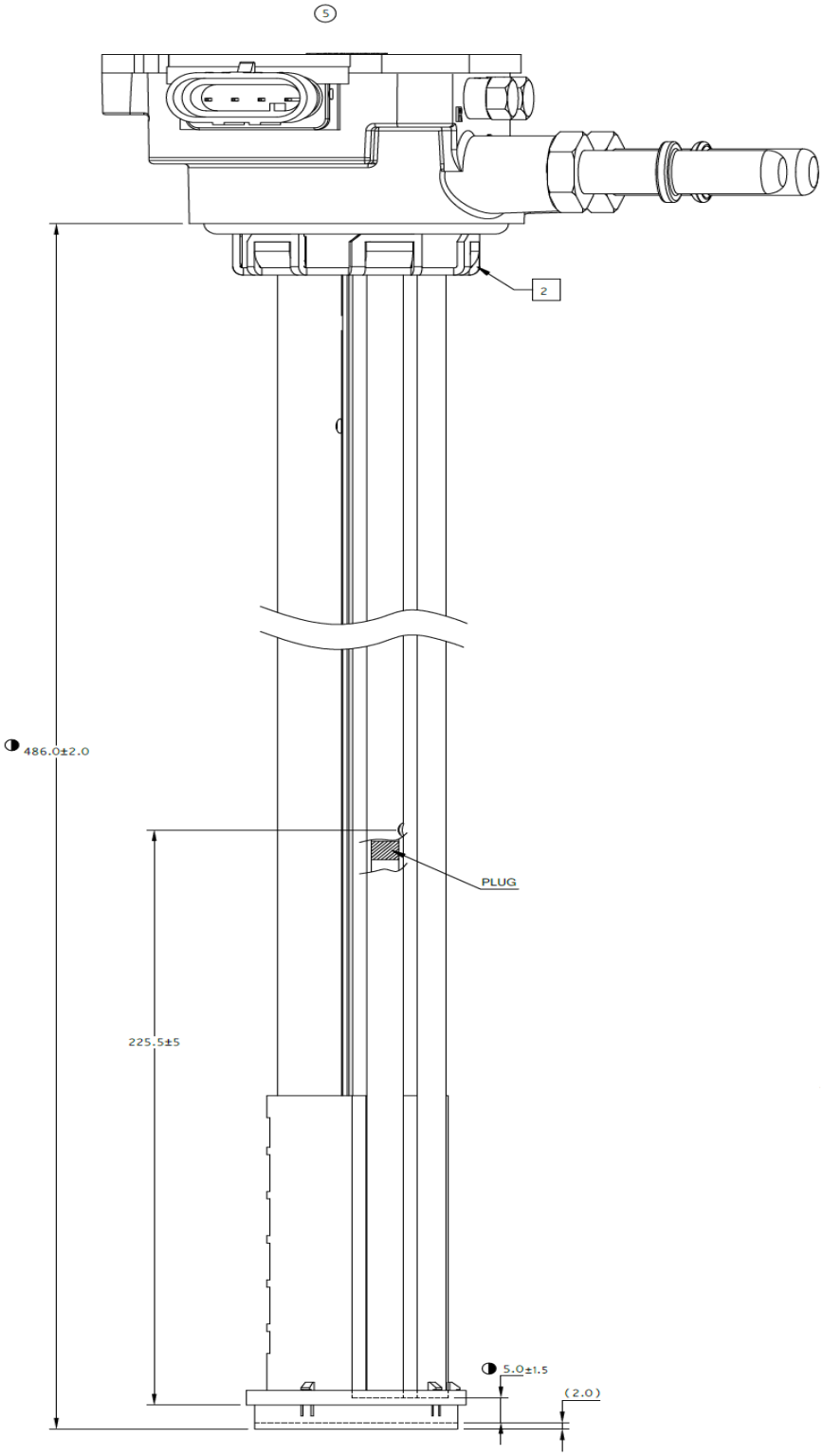






Variant 3 : 225 Ltr. & 350 Ltr.

View From Arrow X



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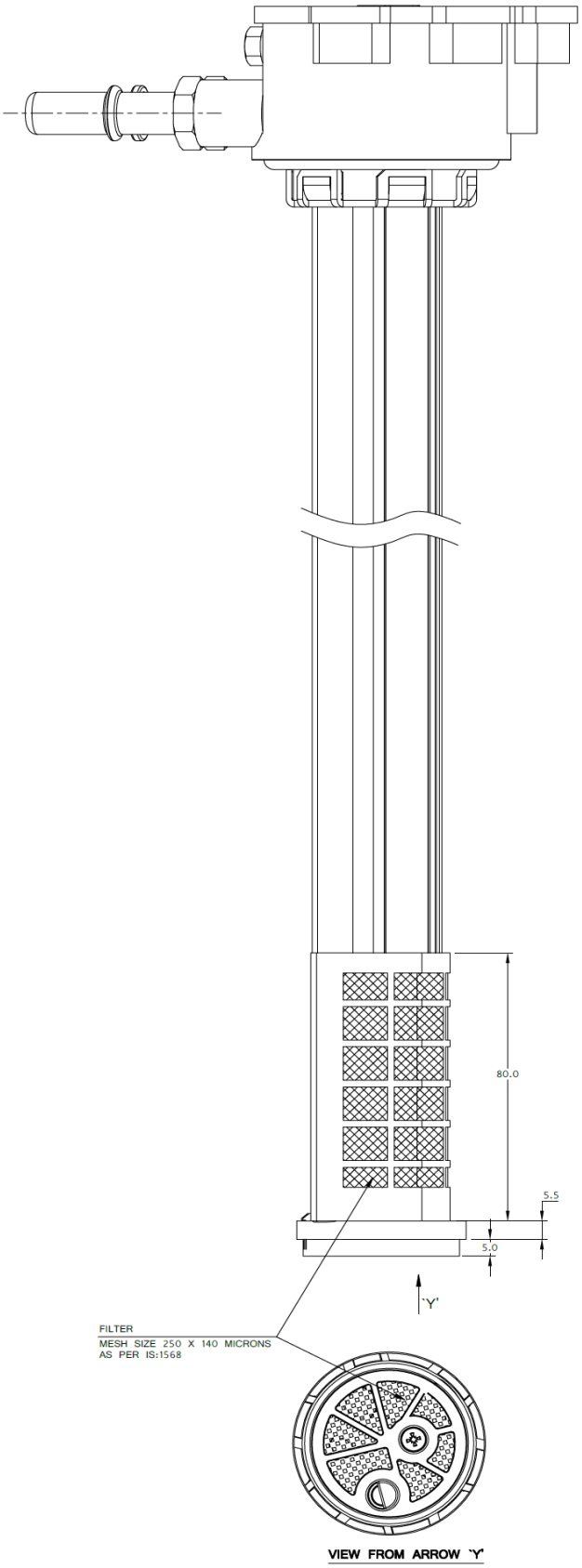

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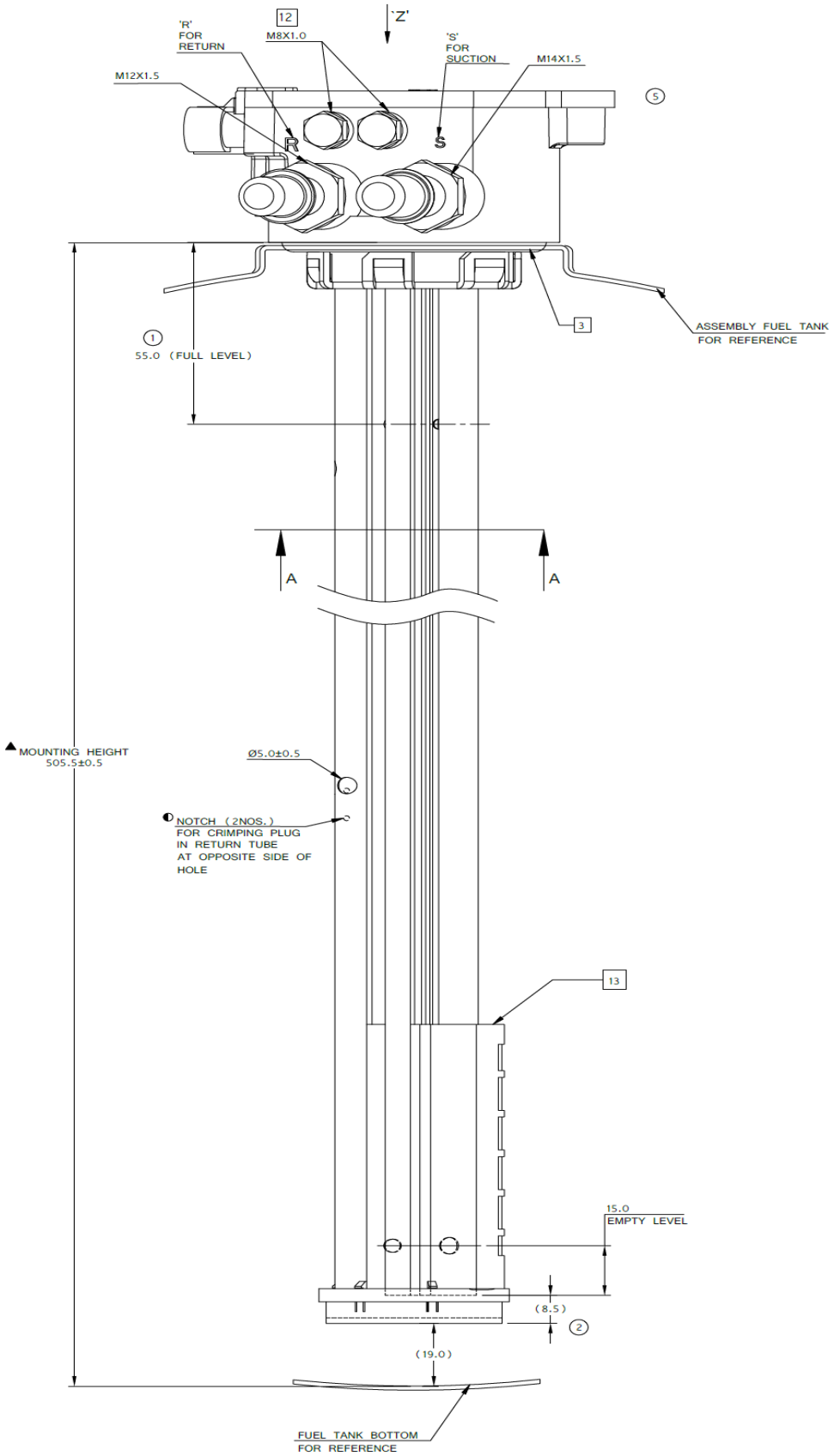
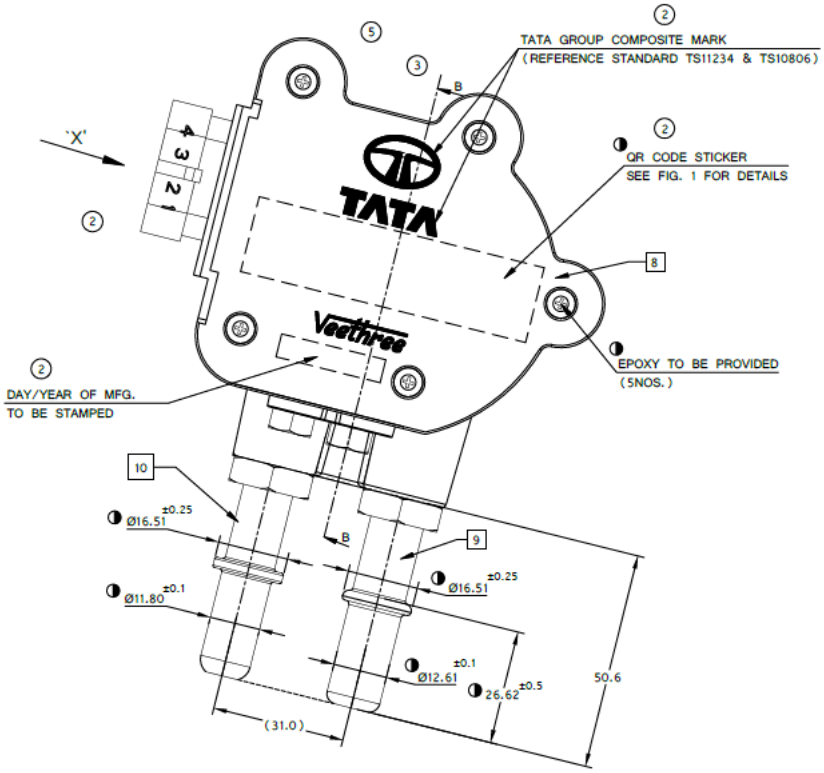
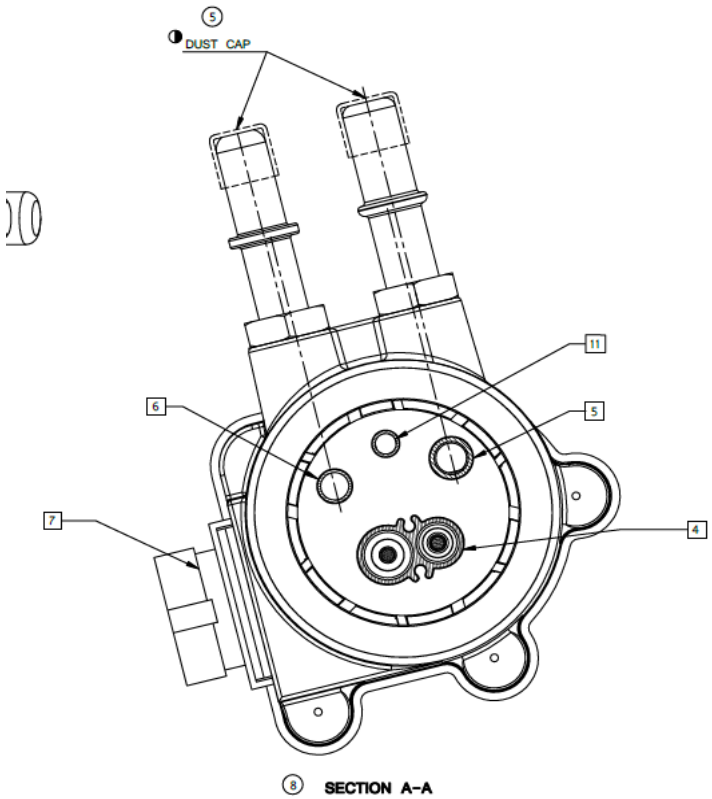




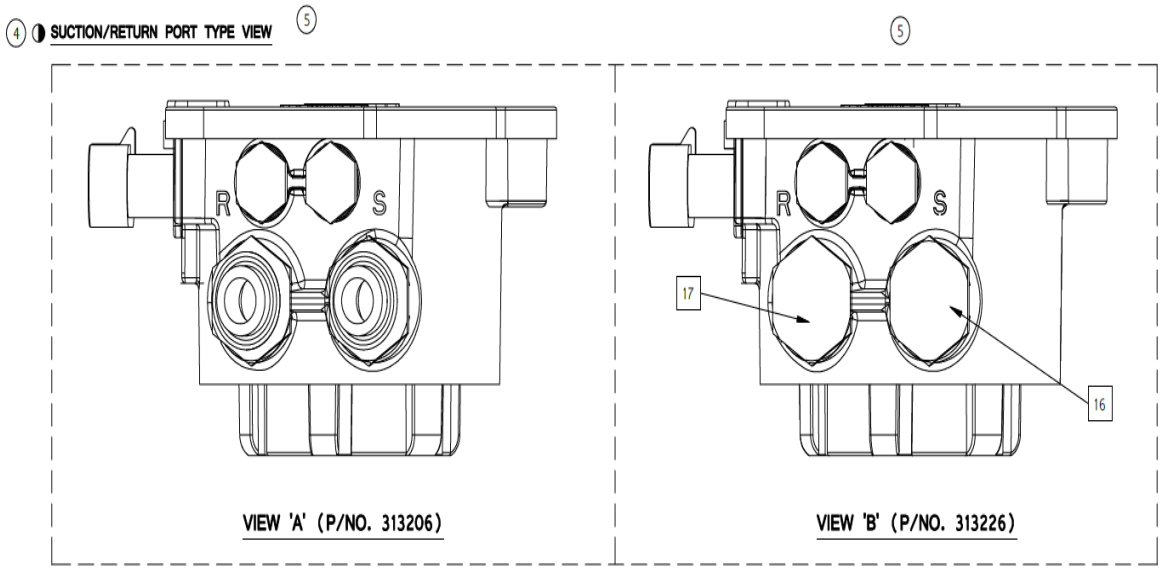
(FITTINGS DIM. AS PER SAE J2044)

VIEW FROM ARROW 'Z'



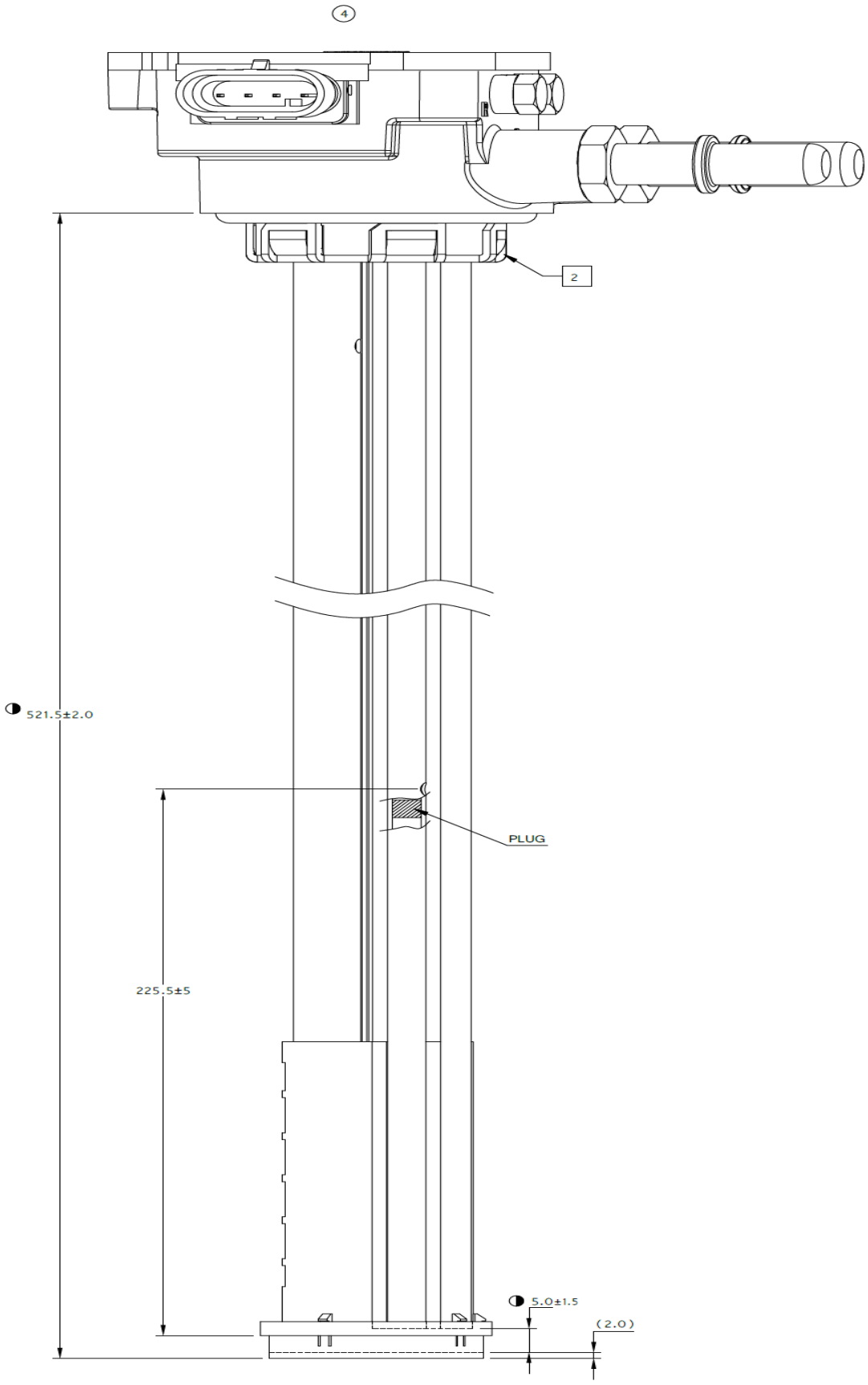
SECTION A-A

Suction/Return Port Type View

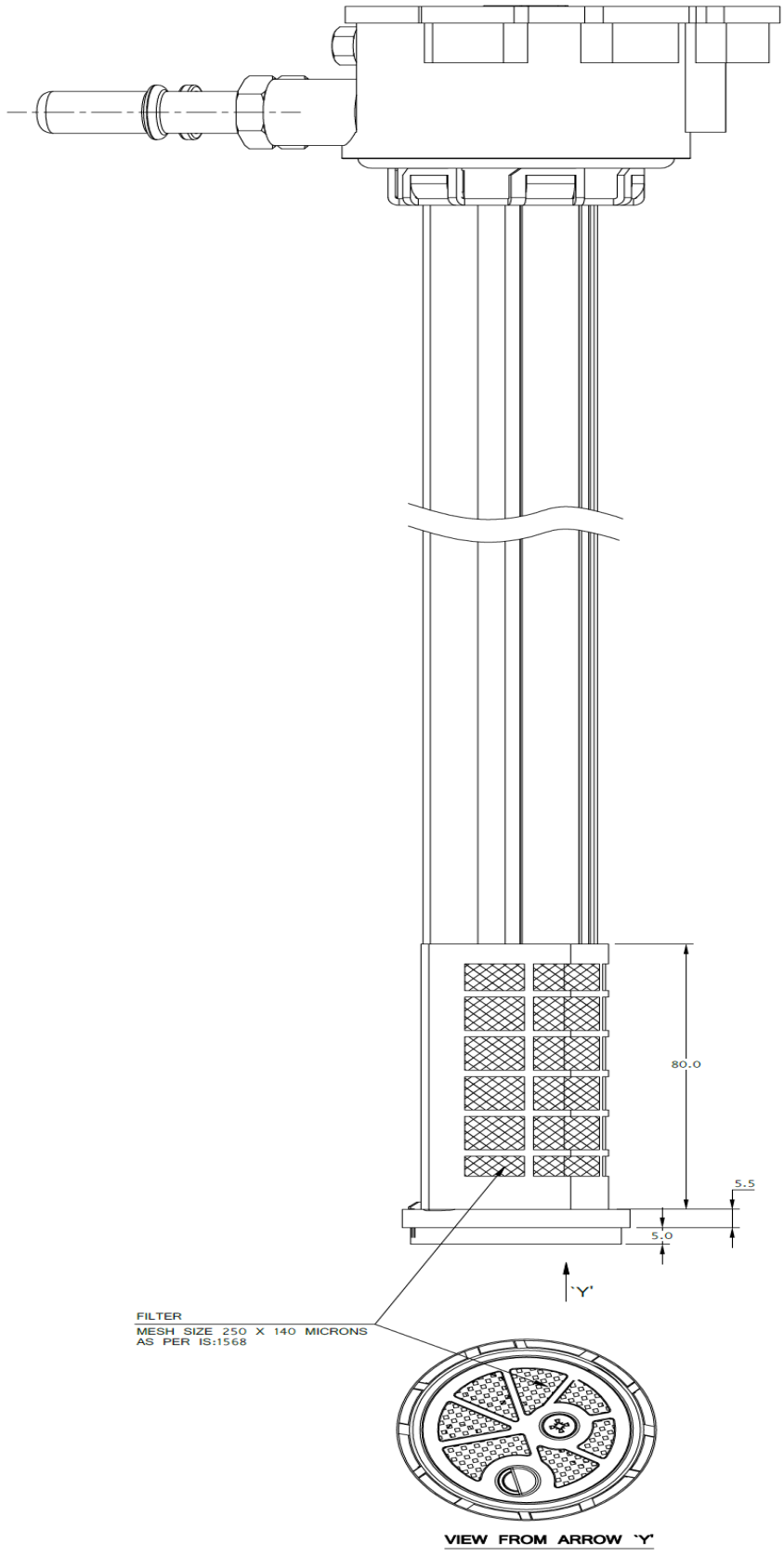


Variant 4 : 192 Ltr.

View From Arrow X



View From Arrow Y



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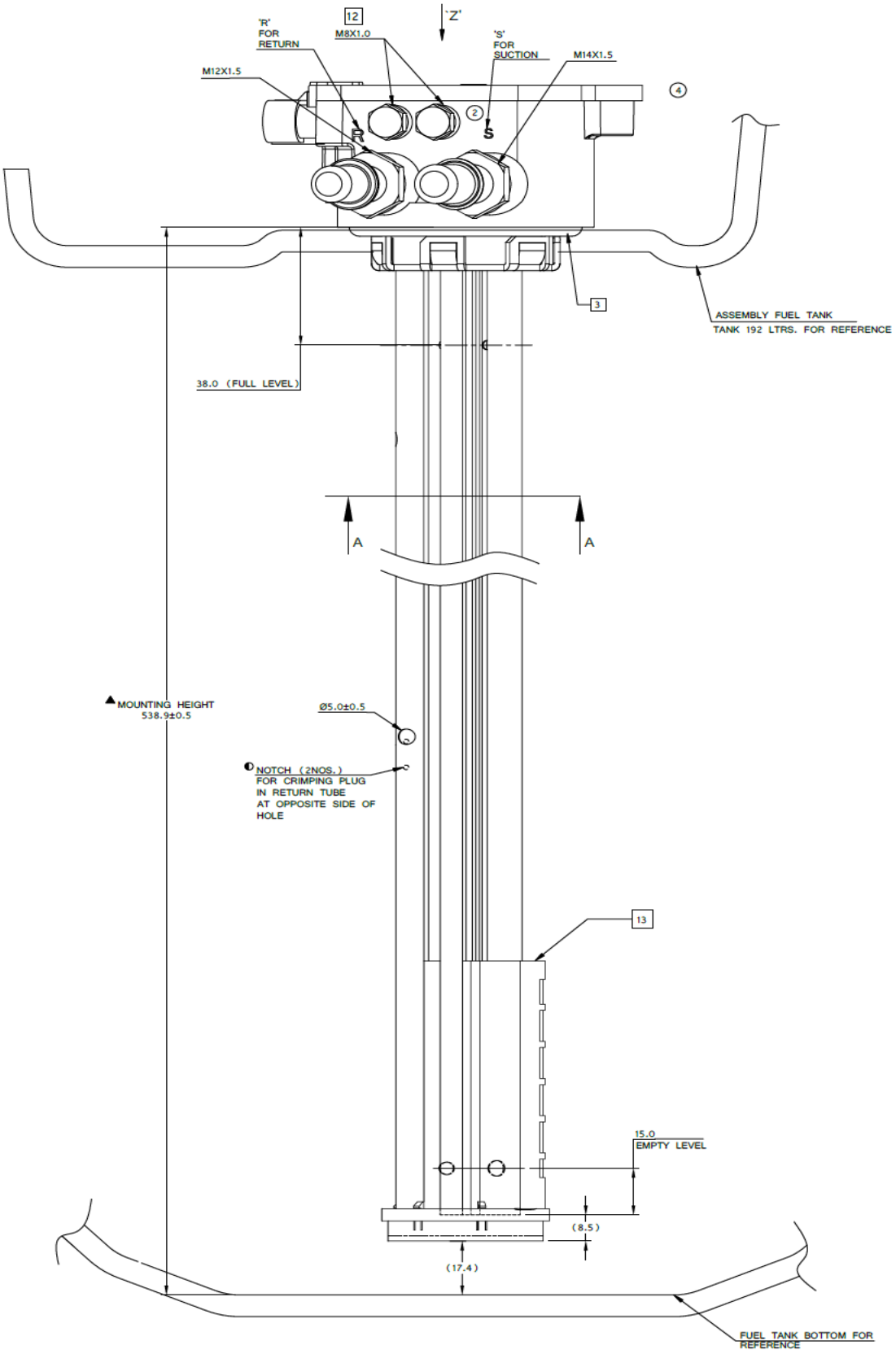
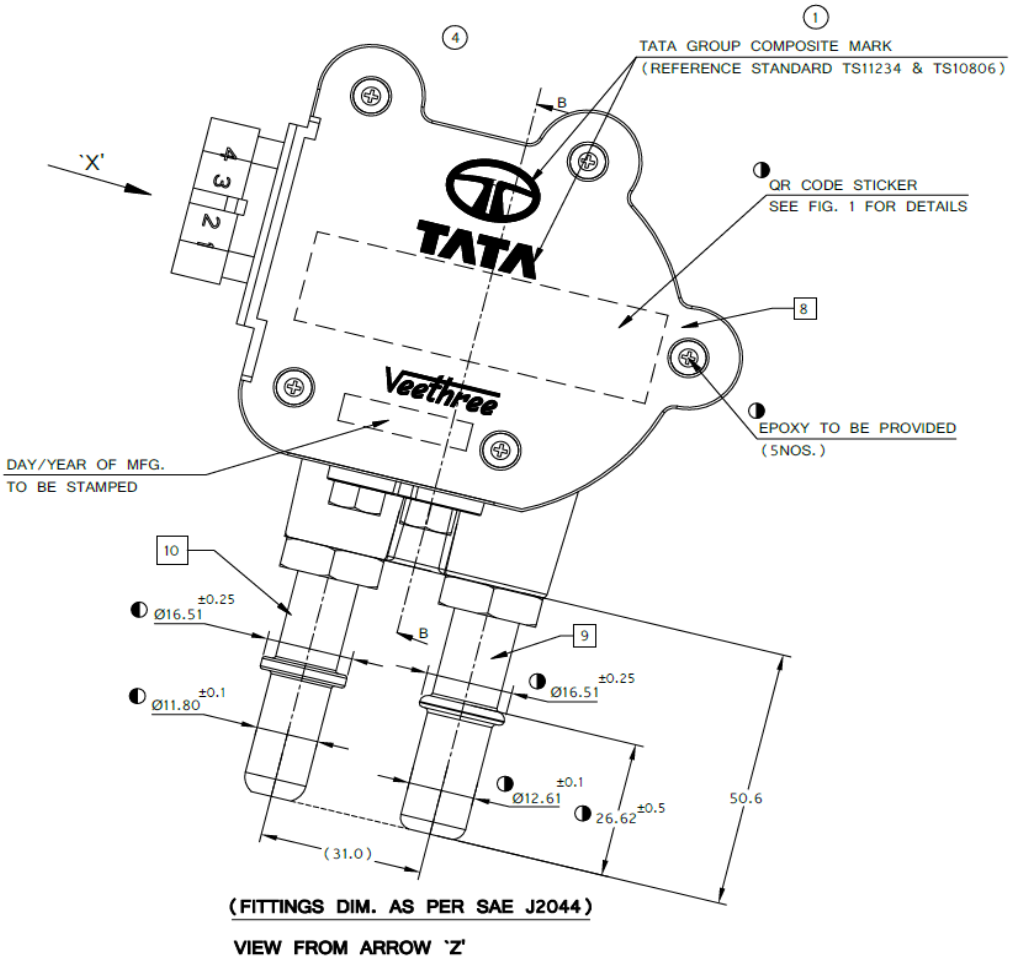
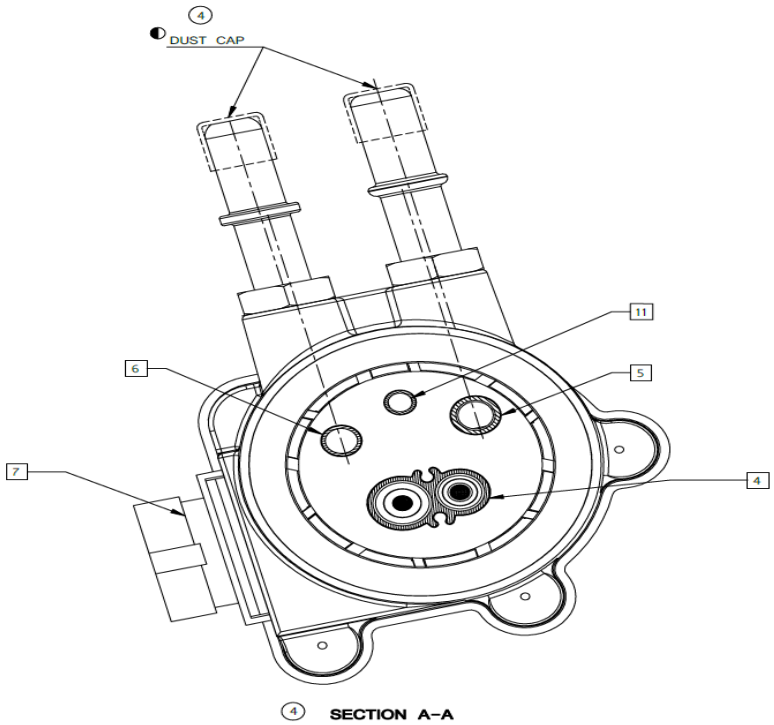
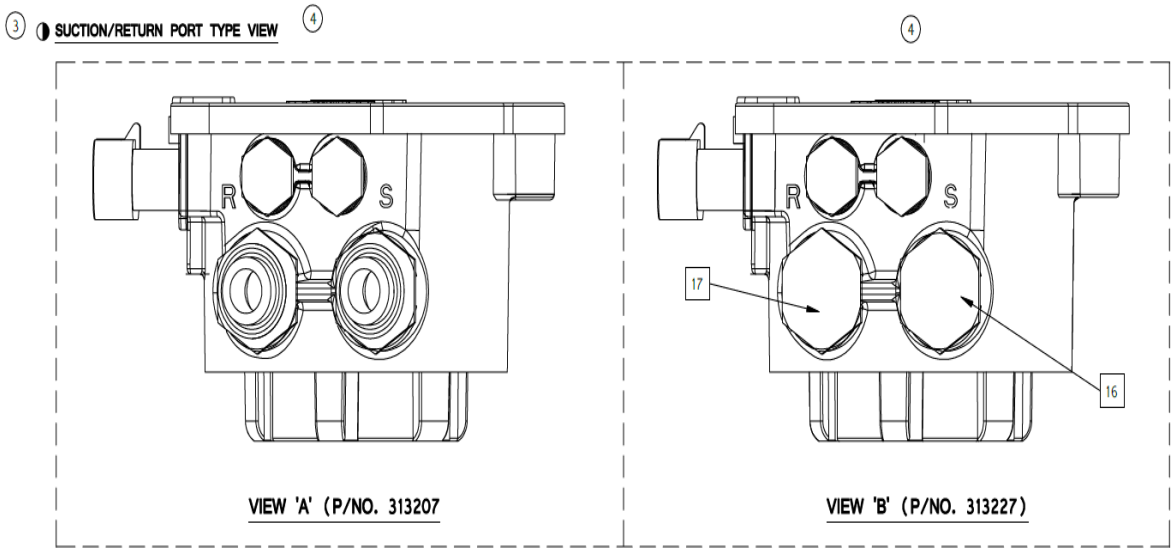


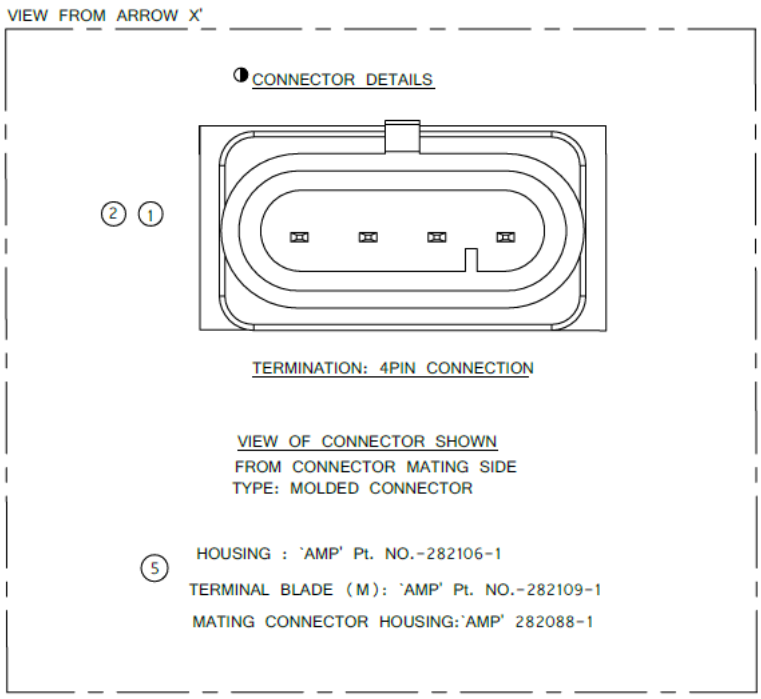




Suction/Return Port Type View

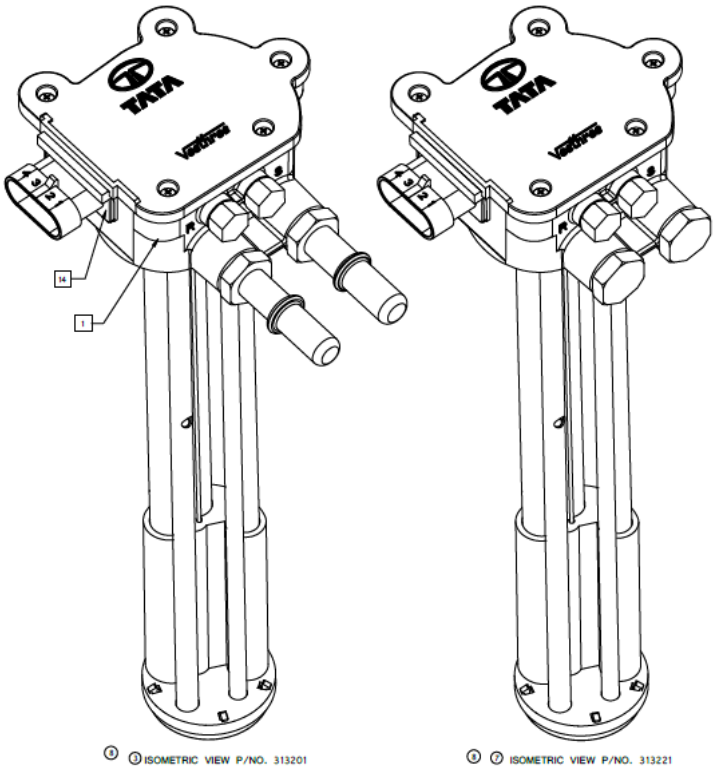


6. Connector Detail



Connector Configuration	
Pin No.	**Type**
1	V+ (Supply)
2	V- (Ground)
3	Signal Out (0.5-5V)
4	For Flashing (Through LIN)

7. Operating Principle



1. The software takes capacitance information from three channels;
    a. P0 refers to values taken from the electronics only. No capacitance probe connected.
    b. P1 refers to values taken from the measuring probe P1. The capacitance probe with the 4mm outer diameter PTFE and 12mm inner diameter aluminium tube is connected.
    c. P2 refers to values taken from the measuring probe P2. The capacitance probe with the 5mm outer diameter PTFE and 10mm inner diameter aluminium tube is connected.
2. Set up probe output, output range and high/low alarm levels etc using GUI setup screen.
3. Calibrate probe in Diesel:
    a. Do not pre-wet probe before taking empty readings
    b. Power up at empty with calibration pad connected to ground (for 10 seconds)
        i. Value of *P1_at_empty* is recorded 16 bit
        ii. Value of *P2_at_empty* is recorded 16 bit

iii. Value of *P0_at_empty* is recorded. P0 is the value obtained when both probes are deselected. 16 bit

c. Remove ground connection from calibration pad and insert in diesel up to full level. Reconnect calibration pad to ground (for another 10 seconds)

i. Value of *P1_at_full* recorded 16 bit

ii. Value of *P2_at_full* recorded 16 bit

d. Calculate value of P1 raw span:

raw_p1_span = P1_at_full – P1_at_empty 16 bit

e. Calculate value of P2 raw span:

raw_p2_span = P2_at_full – P2_at_empty 16 bit

f. Calculate m. Constants 14.4 and 7.07 are derived from multi fluid testing:

m = 14.4 – (7.07 x (raw_p1_span) / (raw_p2_span))

g. Calculate & record divisor at calibration. Constant 6.3 derived from multi fluid testing:

div@cal = (m x (raw_p1_span) / (raw_p2_span)) – 6.3

h. Calculate value of probe span:

p1_span = raw_p1_span / div@cal

i. Probe now fully calibrated

4. Probe now inserted into application fluid. Calculate current level in probes as follows:

a. Temperature effects on Electronics.

$P0_x = P0 - P0\_at\_empty$
If this is negative then set negative flag
NEG = 1
and create complement
$P0_x = (P0_x \ XOR\ 1111111111111111) + 1$

b. Temperature effects on Probe 1. Value of constant, 1.4, is based on empirical data. Value will be negative if negative flag set:

P1_drift_factor = 1.4 x (P0 - P0_at_empty)

c. Temperature effects on Probe 2. Value of constant, 1.05, is based on empirical data. Value will be negative if negative flag set:

P2_drift_factor = 1.05 x (P0 - P0_at_empty)

d. Current level in Probe 1.

p1 = P1 - P1_drift_factor – P1_at_empty

e. Current level in Probe 2

p2 = P2 – P2_drift_factor – P2_at_empty

f. Calculate live divisor

div = m x (*p1/p2*) - *6.3*

g. Average divisor is

$div\_average = (div_n + div_{n-1} + div_{n-2} \ldots\ldots + div_{n-15}) / 16$

h. Lower limitation on value of divisor is

0.97 x div@cal

i. Every 15 minutes the average value of divisor is stored to EPROM. The EPROM has 1 x 10^6 write cycles so assuming 24 hour operation the probe has a life of 28.5 years.

div_average_store = div_average

j. At low immersion levels the divisor calculation can be affected by turbulence and mechanical variations (probe eccentricity). To stop the calculation at low levels, a 20% diesel fill limitation is used

If p1 < 0.2 x raw_P1_span,

then ignore *div_average* and use *div_average_store*

k. At power up condition, before a new divisor can be calculated, stored divisor is used. In the case of switching off and refilling the tank with a different fluid, an error might be apparent for first 5-10 seconds after power up while recalculation occurs.

l. Calculate level of fluid

Q1 = p1/ div_average /p1_span

m. Level Q1 is turned into a PWM signal from 0 to 1024. At this point the lower output offset and span are taken into account.

PWM 0 = 0% +ve duty cycle (output from micro is 0V)
PWM 1024 = 100% +ve duty cycle (output from micro is 5.1V)

8. Variants and calibration

Variant 1 : 365 Ltr.

S.NO.	FUEL LEVEL	HEIGHT FROM FUEL TANK BOTTOM (mm)	OUTPUT VOLTAGE (V) (±2% OF FULL SPAN) ①	FUEL CAPACITY (L) (±1LTR)
				365 LTR
1	FULL	555	5.0	365
2	3/4	425	3.85	267
3	HALF	300	2.75	179
4	1/4	175	1.64	91
5	EMPTY (HIGH)	110	1.07	47
6	EMPTY (LOW)	44	0.5	3.22

Variant 2 : 300 Ltr. & 280 Ltr.

S.NO.	FUEL LEVEL	HEIGHT FROM FUEL TANK BOTTOM (mm)	OUTPUT VOLTAGE (V) (±2% OF FULL SPAN)	FUEL CAPACITY (L) (±1LTR) ①	
				300 LTR FUEL TANK P/N. 5088 4710 0104	280 LTR FUEL TANK P/N. 5119 4710 0105 ④
1	FULL	625	5.00	300	293
2	3/4	476	3.85	230.7	220
3	HALF	334	2.75	151.6	144
4	1/4	190	1.64	72.26	69
5	EMPTY (HIGH)	117	1.07	33.1	31
6	EMPTY (LOW)	43	0.5	5.8	5.6

Variant 3 : 225 Ltr. & 350 Ltr.

S.NO.	FUEL LEVEL	HIGHT FROM FUEL TANK BOTTOM (MM.) ①	OUTPUT VOLTAGE (V) (±2% OF FULL SPAN)	FUEL CAPACITY (L) (±1LTRS.)	
				225 LTRS	350 LTRS
1	FUEL	450	5.0	225	349.7
2	3/4	346	3.85	175.6	272.5
3	HALF	246	2.75	116.6	180.9
4	1/4	146	1.64	57.9	89.8
5	EMPTY (HIGH)	94	1.07	31	48
6	EMPTY (LOW)	42.5	0.5	9.8	15
7	DEAD VOLUME	27.5	0.5	5.1	8

Variant 4 : 192 Ltr.

S.NO.	FUEL LEVEL	HEIGHT FROM FUEL TANK BOTTOM (MM.)	OUTPUT VOLTAGE (V) (±2% OF FULL SPAN)	FUEL CAPACITY (L) (±1LTRS.)
				192 LTRS
1	FULL	501	5.0	192.0
2	3/4	383	3.85	139.0 (2)
3	HALF	271	2.75	98.15
4	1/4	157.5	1.64	51.1
5	EMPTY (HIGH)	99	1.07	27.4
6	EMPTY (LOW)	41	0.5	5.4
7	DEAD VOLUME	25	0.5	2.8

9. Mechanical Specifications

- Sensor head of fuel sensor are suited for mounting of fuel tank with Ø50.5 mm hole. (As per view 'C')
- Fitment of fuel sender – Bayonet type with 'O' ring, use proper tool for fitment of fuel sender in fuel tank
- Installation torque – Vertical force at least 400N. maintain the vertical press and rotate the gauge 30º clockwise.
- Do not use more than 45Nm. There should be no leakage of fuel after the unit is tightened
- Suction/return fitting/plug torque - 20±5Nm
- Filter pull out force after assembly should not be less than 8.0 kg-f
- Sealing of sensor head – IP69K

10. Electrical Specifications

- Operating voltage – 9-32 VDC with 80V over voltage protection
- Supply current – 15mA @12 VDC & 23mA @24 VDC
- Output signal – 0.5 VDC (Empty) to 5 VDC (Full)
- Resolution – 10mV
- Accuracy - ±2.0% @20ºC (+68ºF) in diesel with dielectric constant value of 2.1 to 2.3
- Sleep current – 10mA Max.

11. Environmental Specifications

- Operating temperature range : -40 to +85 Deg Celsius
- Storage temperature range : -40 to +90 Deg Celsius
- All steel parts are to be zinc plated and trivalent yellow passivated (As per FeZn8 Cr III Y as per TS : 10812)

12. General Specification

- Vehicle operating system voltage – 24V DC with negative ground
- Fuel sender to be calibrated at all fuel indication level
- The fuel sender is self-calibrating, which means its accuracy stays within ±10% even if used in different fuel, as long as dielectric constant of fuel is within 1.75 to 3.0
- The PCBA should have conformal coating.
- Guiding strips (2 nos) to be used in both the probes assembly.
- Dimensions without tolerance are for reference only.
- Loctite SI 5910 should be used for sensor head sealing.

13.Flashing Through Bootloader

It supports the flashing of programming file using LIN driver. After flashing calibrate?

LIN details –

- Single wire (+GND)
- Supports baud rate upto 1-20 kbps, 6-bits identifier
- Upto 40 mtr bus length
- Variable data length – 2, 4, 8 bytes
- Operating voltage – 12V
- Uses time triggered scheduling with a guaranteed latency time
- Supports sleep and wake up mode
- Less harness than CAN, single wire of 5V
- LIN master serves as a gateway on the CAN bus
- Deterministic rather than event driven, no bus arbitration
- Does not have hardware controller and has no hardware error diagnostics

14.Testing Requirements

S. No.	Test Description	Reference	Acceptance Criteria
1	Visual Check	As per Drawing	As per Drawing
2	Height Vs Voltage Check	Work Instruction no. 251 Issue 07	Work Instruction no. 251 Issue 07
3	Leakage Test	”	”
4	Volume Vs Voltage Check (System Level Check)	”	”
5	Tri Voltage Tri Temperature Functionality Check	”	”
6	Insulation Resistance Check	”	”
7	Dielectric Strength Test	”	”
8	High And Low Storage Temperature Test	”	”

9	Dry Heat Test	”	”
10	Cold test	”	”
11	Rapid Temperature Change Test	”	”
12	Thermal Shock Test	”	”
13	Water Spray Test	”	”
14	Salt Spray Test	”	”
15	Resistance To Fluid	”	”
16	Pressure Cycle and Vacuum Test	”	”
17	Connector Engage and Disengage Test	Work Instruction no. 260	Work Instruction no. 260
18	Radiated Immunity	Work Instruction no. 257 Issue 07	Work Instruction no. 257 Issue 07
19	Radiated Emission	”	”
20	Bulk Current Injection	”	”
21	Conducted Transient Immunity along signal lines (3a and 3b)	”	”
22	Conducted Transient Immunity along signal lines Pulse 1, Pulse 2, Pulse 3, Pulse 4 and Pulse 5a	”	”
23	Electrostatic Discharge Test (Unpowered)	”	”
24	Electrostatic Discharge Test (Powered)	”	”
25	Conducted Emission Along Supply and Signal Lines	”	”
26	Random Vibration Test	Work Instruction no. 251 Issue 07	Work Instruction no. 251 Issue 07
27	Slosh Test	”	”
28	Contamination Test (MOEST)	”	”
29	Drop Test with packaging	”	”
30	Hot Plugging Test	Work Instruction no. 257	Work Instruction no. 257
31	Vehicle Level Fitment and Functionality Check	Work Instruction no. 251 Issue 07	Work Instruction no. 251 Issue 07
32	Tear Down Analysis	”	”
33	AIS004 Part3 Certification	As per AIS004	As per AIS004

15.Future Development

- We can provide voice feedback system.
- We can add vibration sensor to the vehicle. In case when vehicle is locked and somebody is try to open the vehicle lock then vibration will be produced and vibration sensor can sense this vibrations and turn on the buzzer.
- It can be used for indication of BIO Fuels, to indicate the KMPL in vehicles, to monitor the average fuel consumption in vehicles, can be used in vehicles with different sizes and shapes of tank.