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Design of Terminal Automation System

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Abstract: This paper is about the design of detailed process involved in the automation of the terminals in the oil and gas industry. Paper discusses about different levels included in the terminal automation system, the different equipment involved and the design of them.

Abbreviations: **TTES (**Tank Truck Entry Scheme**), LRC (**Load Rack Computer**), FAN (**Filling AdvisoryNote**), TLF (**Tank Lorry Filling**), CR (**Card Reader**), RIT (**Remote Interaction Terminal**), TAS (**Terminal Automation System**)**

The oil and gas industry is the one of the most important sectors of Indian economy. We have been using oil and gas for the past thousands of years. Oil is mainly found in natural reservoirs or may be collected from seepage or tar ponds.

Since both oil and gas are highly inflammable, it is very risky to deal with it. So many hazardous events have occurred due to carelessness and some system made mistakes. Terminals are the place from where we dispatch the refined products of the refineries. Most of the products are highly inflammable and they have high cost also. So we need a highly safe, risk free and obviously profitable environment in this field .This scenario brings out the relevance of automating this industry. The oil and gas market is the fastest growing industrial market for process automation today. Here we can discuss about the automation of terminals in the oil refineries.

Even though terminals are the last part of the refinery, they are the most unavoidable part of many industries across the world, they needs terminal automation system which performs in faster and efficient way. It includes starting from the pipes which carries the oil, tanks used for storage, trucks and wagon used for transporting the oil, the bays from where the trucks are filled etc. We can include the whole processes in three headings.

- Field and field equipment
- Control room and SCADA
- PLC

Field and field equipment include all the pipe lines, tanks, trucks, wagons, batch controllers, card readers, sensors , radar gauges, RTDs, air eliminators, strainers, valves etc.

Control room includes the equipment such as servers, mod buses, switches, PCs, RTUs etc. This will receives the field signals through RS 232/485 cables. All the systems in control room will be connected in the LAN network. SCADA is used to control all the processes from the control room remotely.

The control signal from SCADA will energise the PLC and it will act. Two types of PLC are used in terminal automation. Process PLC and Safety PLC. Process PLC controls the pumps, barrier gates, DBBVs, etc. Safety PLC is used for safety purposes like ESDs.

The process of Terminal Automation starts when truck entries in the terminal and it will end when the truck leaves the terminal after filling the fuel. In between this there are a lot of process are occurring like SAP TAS interfacing , fan generation, entering licensed area, batch controller working , loading , truck cancellation, bypassing, truck aborting etc. The success of Terminal Automation System completely depends upon these different processes in it.

TAS has mainly 8 subsystems. They are

I. SAP-TAS INTERFACE

SAP-TAS interface is developed to automate the data transfer between client and server TAS system. It consists of built in control and executable scripts for its proper functioning.

II. GANTRY AUTOMATION SYSTEM

[2]The gantry automation system is the heart of the terminal automation system. It is mainly about the transfer and control of the products. It includes the batch controller unit, Proximity Card reader, Overspill Prevention Device, Static charge

grounding device, Loading Arm, Loading Arm position detection device cum arm interlock, Digital Control Valve, Strainer cum Air eliminator, Flow meter, Pulse transmitter, and Temperature and Pressure transducers.

III. ADDITIVE INJENCTION AND BLENDING SYSTEM

[2]The diversified demand of fuels in today's era is driven by various factors which include the base product modification. It includes accurate blend of two or more products enhancing the capability of base product by injection of special additive, to mark the product with injection of the marker. The additive injection and blending solutions offered by us helps in operation flexibility and enables to load multiple products from same loading arm and reduce dependency on multiple storage tanks.

IV. TANK FARM MANAGEMENT SYSTEM (TFMS)

[2]This subsystem manages the product stored in large tank and constantly monitors the product level in each tank. It also monitors the product level in each tank and other important information like density and temperature. Components of TFMS includes tank gauges, temperature sensors, tank slide indicators, water bottom sensors , communication interface units and tank farm software.

V. TANK TRUCK ENTRY SCHEME (TTES)

This subsystem manages the FAN (Filling Advisory Note) generation process. When the packet data came to server from client SAP it will generate FAN.

VI. TANK TRUCK REPORTING SYSTEM (TTRS)

When a truck enters the parking lot, the RFID card reader of the parking lot will read the barcode of the truck. According to that the details of the truck will load to our TAS from database. Here we have two philosophies - truck pending and truck waiting.

VII. CONTROL ROOM SUBSYSTEM

This subsystem is used to control and monitor the operation of entire Terminal Automation System in remote mode. It includes redundant Load Rack Computers (LRC), Operator Interface Computer (OIC), printers, networking components, PLC, UPS, panels, consoles and related systems. The SCADA will be installed in the LRCs.

VIII. ACCESS CONTROL SUBSYSTEMS

This subsystem is responsible for controlling vehicle entry and exit at the facility. The various components include barrier gates, card readers, traffic lights, vehicle sensors, a security station and related accessories.

BATCH CONTROLLER UNIT

[1][2]The proper working of TAS is mainly based on the working of Batch controller unit. A batch controller is an intelligent device designed for loading operation in terminals of petroleum refineries and oil marketing terminals. This will control and manage the transferring of different petrochemical products onto road tankers and rail cars. Precisely batch controller is an intelligent device used to deliver the set amount of liquid along with control flow, BC monitors digital as well as analog parameters essential for continuing batch delivery process. There are different make of batch controllers are available in the industry like SMARTLOAD (GE), CONTREC (HONEYWELL) etc. The main functions of batch controller are Batch delivery, Blending, Additive injection, Meter Proving, Transaction Storage / User Defined Transaction Ticket, LPG / Pressure Control, Calibration Monitoring.

CARD READER UNIT

[2]The card reader is designed to restrict the access control of unauthorized person / vehicle is hazardous and non hazardous harsh area. This is certified to ex ia, IIC, T6, the Sentry is intrinsically safe and therefore suitable for use in most hazardous of area, including those certified as zone 0, where there is a constant risk of an explosive atmosphere. It can be configured to read a range of different card technologies.

The Sentry comprises a weatherproof box housing the electronics requires to format the card data for transmission to a host computer and a card reader head. One of several card reader head options may be fitted to this box.

SCADA SYSTEM

[1][3]It helps to control the entire operation of the depot starting from truck arrival till its exit from the depot. It also integrates the storage tanks, valves, flow meters, and all the parameters of them to the system. It enable the operator to control the depot with the help of various modules like Configuration module, Operation module, FAN module, Gantry module, System status module. It

provides clean overview of various operations at depot. PLC is also integrated with SCADA system.

TANKS

The tanks are used to store fuels such as Motor Spirit, High Speed Diesel, Naphtha, Aviation Turbine Fuel, Ethanol, Mineral Turpentine Oil etc. The tanks are important part of terminal automation system and it is the place where we want to put our care, because most of the reported accidents are occurred in the tank farm only like 2005 Buncefield fire in UK, 2009 Jaipur fire in India etc. So tanks are provided with maximum safety. Each tank are provided with two radar gauges. Tank is divided into 6 levels such as Low-Low (L-L), L, High (h), H-H and Automatic Overspill Protection System (AOPS). The two radar gauges are considered as primary and secondary. The primary radar gauges will sense the level of the tank. The secondary will sense the above mentioned levels. The data that are needed to the TFMS system is taken from the primary radar gauge and the secondary is hard wired to the PLC system. The inlet and outlet pipes of tanks are provided with DBBV and ROSOV. The tanks are operated in different modes such as

- Receipt
- Dispatch
- Dormant
- Inter Tank Transfer(ITT)
- Recirculation/ Churning
- Maintenance

Receipt mode means the tank is receiving the fuel. It will be from train wagon, pipeline or tank truck. Dispatch mode means the fuel is transferring from the tank. This will also through pipeline, wagon or tank truck. Dormant mode is the idle state. In ITT the fuel from one tank is transferred to other tank. Recirculation is used to rotate the fuel within the tank. This is used mostly in case of MS and ATF.
When we want some maintenance work the tank will in maintenance mode.

DBBV AND ROSOV

[2]All the DBBV will be operated by process PLC though loop topology of two wire modbus communication along with ESD command hardwired with safety PLC.

Local Mode of Operation of DBBV

- Local/Remote selector switch housed in the Actuator should be in Local Mode selection.
- Open/Close through open/close button housed in the actuator.
- Close in the event of ESD (anywhere in the location) activation
- DBBV shall close under ESD condition and from LPBS.

Remote Mode of Operation of DBBV

- Local/Remote selector switch housed in Actuator should be in Remote Mode selection.
- Open/Close through OIC /Push Button Station located outside the dyke wall.
- Close in the event of ESD (anywhere in the location) activation
- Close in the event of Tank Level HH / LL Alarms
- Close in the event of Tank Level HHH Alarm.
- Open/close based on Tank Sequencing Logic automatically if it is in Remote – Auto else needs to be closed from OIC.

As per the philosophy of ROSOV operation, each ROSOV provided with two pushbutton stations, each having set of open and close button for field operation. One station mounted near to ROSOV and other outside the dyke.

- There will be a provision for issuing close command for individual as well as all ROSOV from OIC.
- Open command can be issued from OIC which will be password protected by operator having suitable rights.
- ROSOV shall open only after pressing any one open push button (PB station inside/outside dyke) in the field in case of healthy condition
- In addition to automatic closure of ROSOV by AOPS, these ROSOVs can be closed from the control room or from ESD push button or from local push button station.

For ethanol tanks, IOCL will provide ROSOV at inlet line for the purpose of AOPS operation, to comply with SIL2 loop certification.

DIGITAL CONTROL VALVE (DCV)

Digital control valve is to control the flow as per programmed instructions from the Batch Controller. The Digital Control Valve shall be a diaphragm operated main valve & two solenoid valves. Normally open (NO) solenoid shall connect the valve cover chamber to the upstream pressure, whereas normally closed (NC) solenoid shall connect the valve cover chamber to the

downstream pressure. These NO and NC Solenoid shall be connected to Batch Controller. Batch controller shall control the DCV in multistage flow control operation. These DCVs shall be electro hydraulically operated for white oil. The solenoid valves shall be suitable to hazardous area classification. DCV calibration flow control needle valves shall have stainless steel pad lock arrangement with lock to protect from tampering.

POSITIVE DISPLACEMENT (PD) METER WITH DUAL PULSE TRANSMITTER

The PD meters shall be used for the products (except Naphtha) which are meant for volumetric loading. The PD Meter shall be Double Case Flow Meter consists of a measuring chamber. The measuring chamber shall be calibrated to the meter output i.e. electronic pulses from Pulse Transmitter. It should have a flow range of 240-2400 LPM for bottom loading and 150-1500 LPM for top loading. It should have batch accuracy of +/- 0.05% over the full range and repeatability of +/- 0.02 % over 10:1 flow range. Drop in pressure across the meter should not be more than 0.25 Kg/cm2. Other details shall be as per data sheet. PD meter vendor shall clearly specify the pressure drop across the meter at maximum flow, lower flow limit in LPM for specified accuracy & meter maximum flow limit in LPM.

AIR ELIMINATOR

The Air Eliminator shall be mounted after the Strainer body. It shall consist of a stainless steel float connected to a pilot valve via multiple linkages. When air collects in the Air Eliminator the buoyant force acting on the float reduces & the float drops down along with the pilot valve connected to the linkage & the air escapes through the main valve. As the liquid rises in the Air Eliminator, the floatrises to lift the pilot valve, thereby closing the air release opening of main valve.

STRAINER

The Line Strainer shall be fitted on Flow Meter inlet. The Strainer shall consist of a fabricated body with flanged inlet & outlet connections. The wire mesh basket filter element is to remove the impurities for the liquid. A drain plug is provided to facilitate servicing. Liquid impurities shall get filtered on passing through the filter element & clean liquid flows through the Flow Meter. A differential pressure indicator shall be installed across the body of strainer with isolation valves. Drop in pressure across the strainer should not be more than 0.25 Kg/cm2. Metering System vendor shall ensure that the pressure loss across the Strainer is within limits as mentioned and shall mention actual pressure drop in his meter data sheets.

PLC

All the process logics shall be controlled from the PLC. This process logic shall be written in vendor's own language for e.g., function blocks, ladder diagrams etc. Process Logic required for the plant operation, which shall be taken from P&ID's and translated in terms of logic gates and then into ladder programs.
[2][3]Programs in PLC shall be controlling

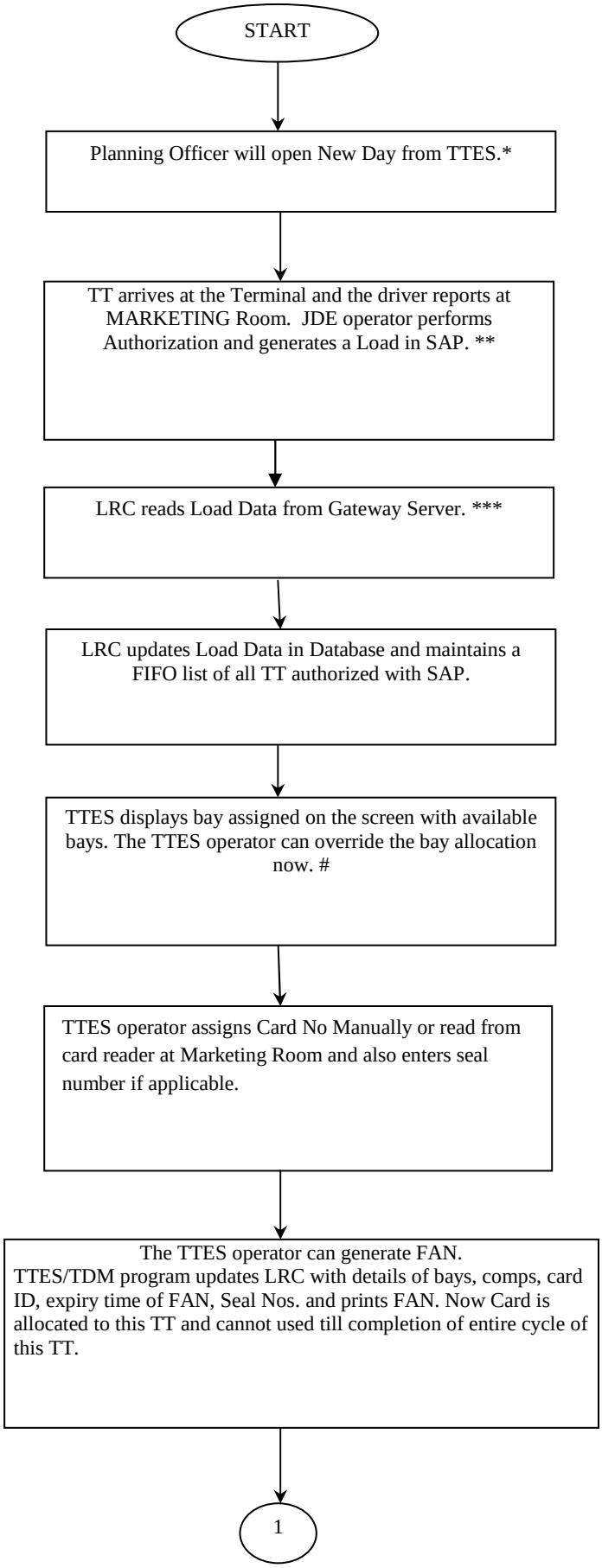
- The pumps operation such as start/stop from OIC, Pump demand processing; pump sequencing, remote / local control etc.
- PLC can control the opening / closing of valves from OIC, remote / local control etc.
- Fire Alarm processing for whole of the plant by controlling the number of Fire alarm pumps in case of Fire at plant can be controlled from PLC.
- PID controllers on various parts of the plant are controlled by the PLC depending on the Set points configured.
- In case of Emergency Shutdown, PLC stops all plant functions such as stopping of Product Loading pumps, closing of Valves, Opening of Barrier gates, Stopping of all batch controller's, Tank level Alarms and ESD repeat signals to pipeline division etc.
- Processing of analog data such as signals from Density meter, Pressure transmitter, Tank level and temperature signals to pipeline division in the form analog signal are controlled by PLC.

These are the main elements and the overall process of Terminal Automation System. The benefits or advantages of this TAS are

- Accountability
- Reduction in Manpower and cost
- Increased efficiency
- Increased flexibility
- Increased security
- Improved customer service and reliability
- Reduced complexity as design and installation

- Improved environment
- Reduced time
- Modular approach
- Increased accuracy and safety
- Accurate and faster management information
- Real time exchange of data with the company's business system

The detailed process of terminal automation system is given below as a flow chart. It includes everypart that concerned to the loading activity in terminals.

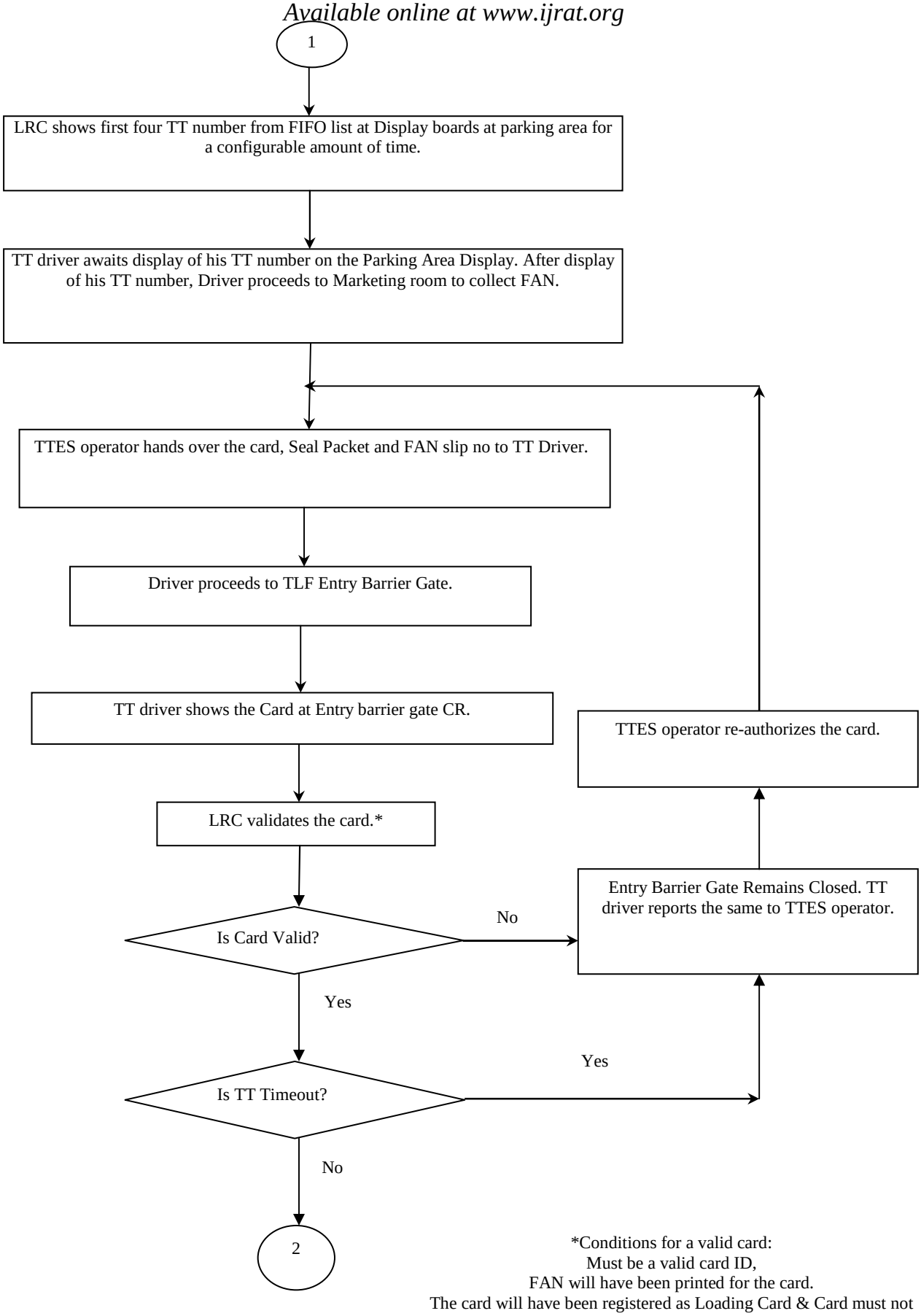


*Open New Day is one time activity in Day and can be done once in Day.

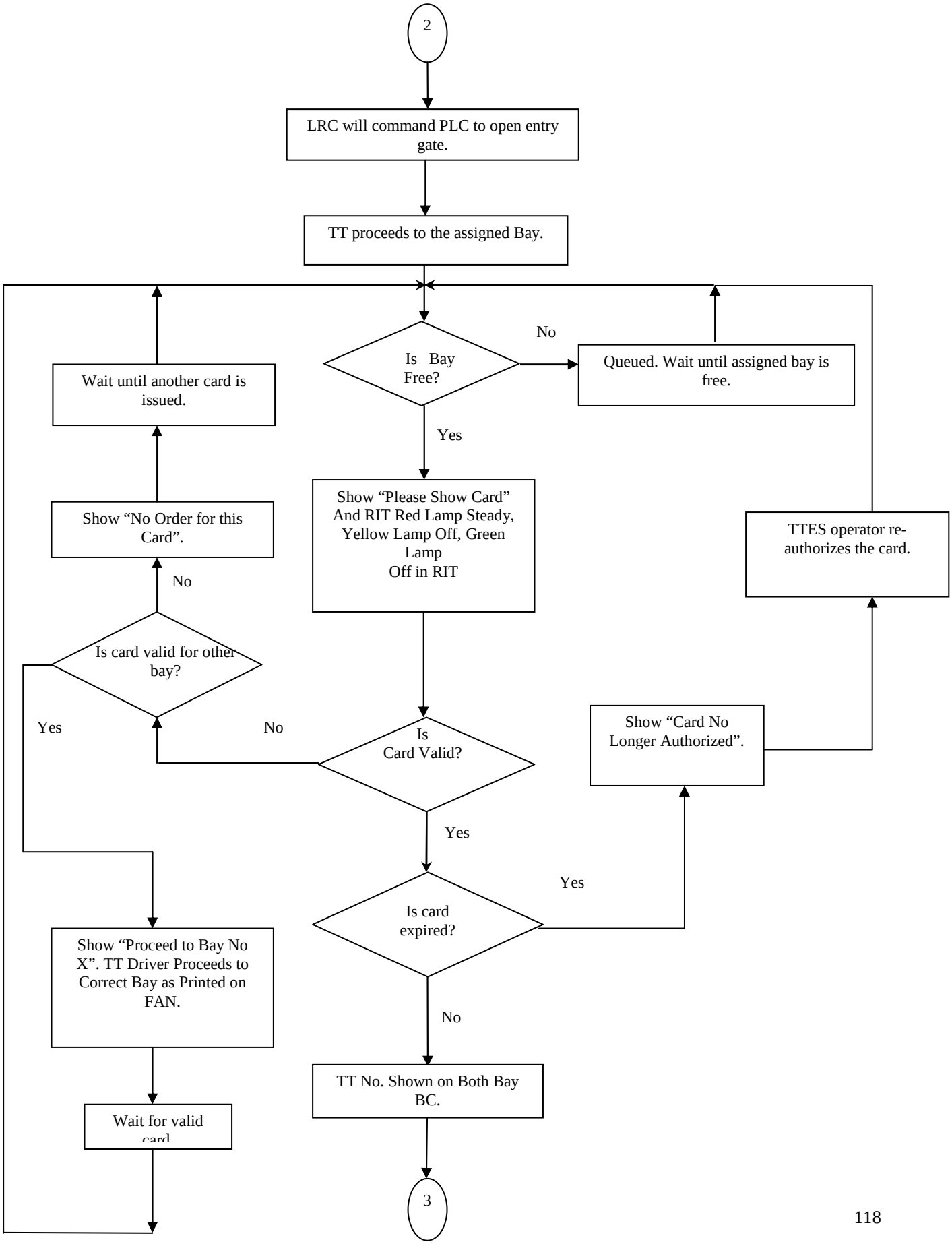
** In the event SAP server is down, TTES will generate FAN on local mode with no commercial validation.

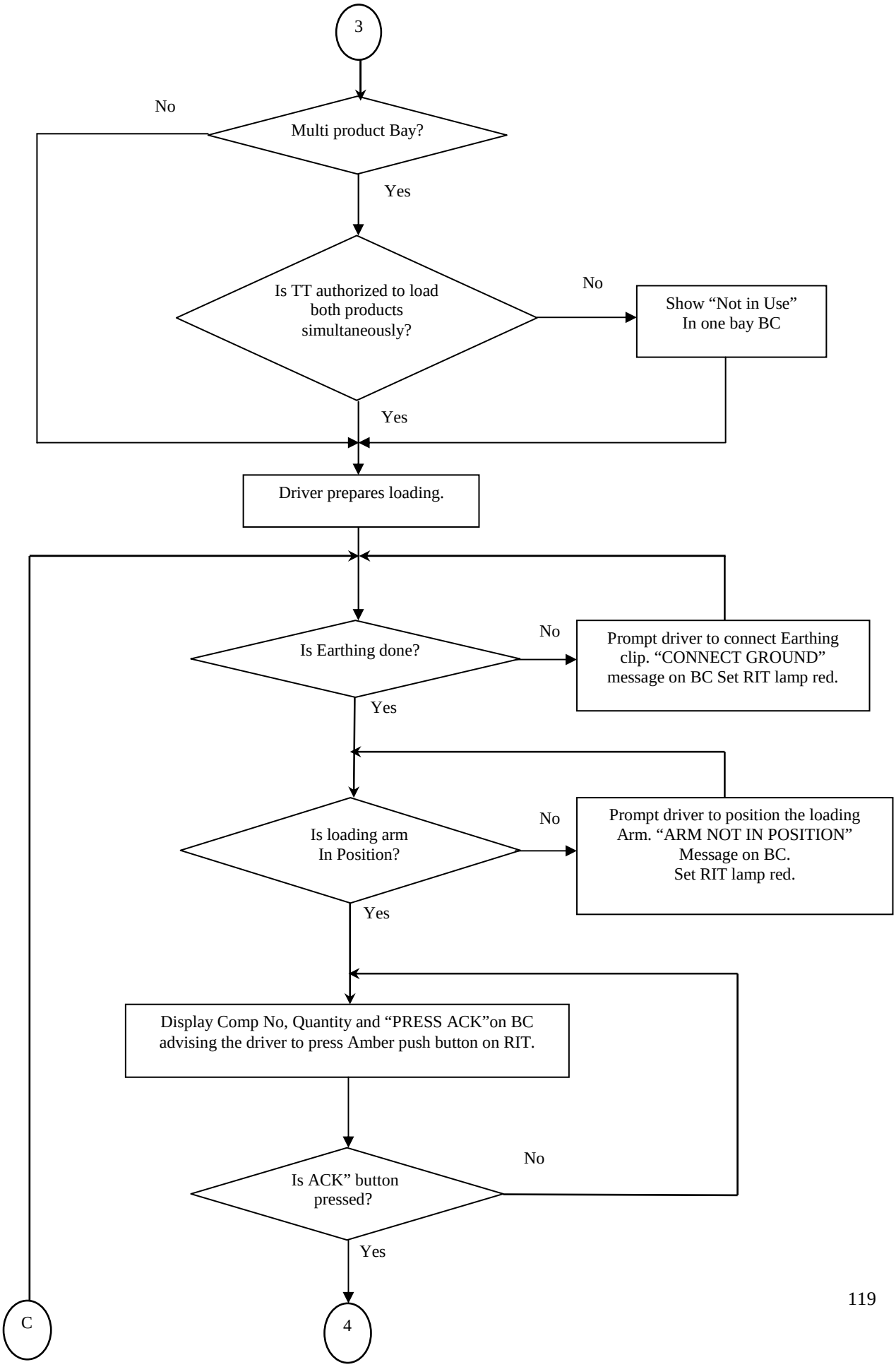
*** In the event that the LRC server is down, the SAP will generate filling advice in a non-automated mode.

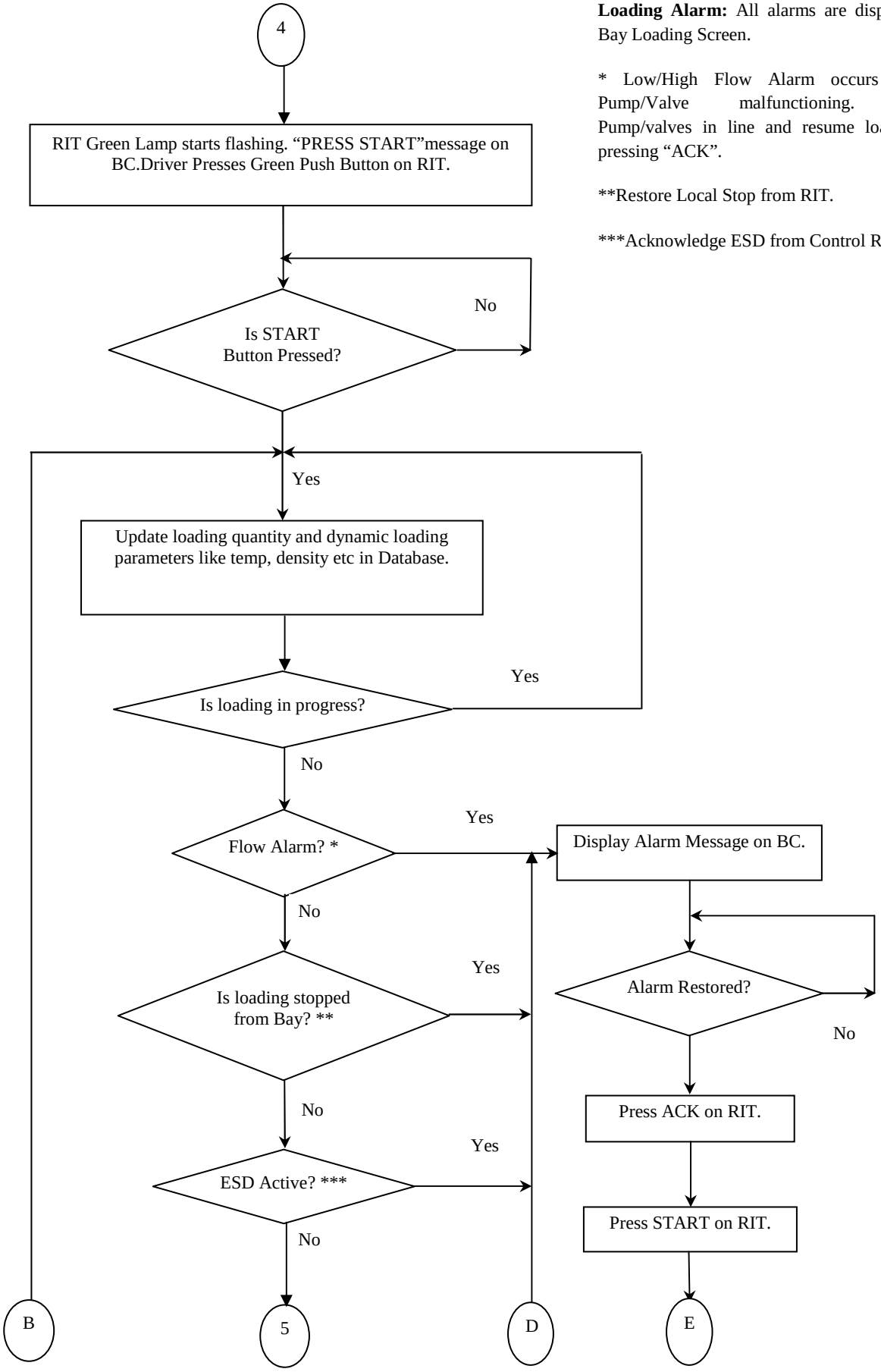
#LRC maintains 1+2 Criteria when queuing TT for each bay in normal condition. In This scenario priority truck get first priority for filling. Other 2 trucks wait till priority truck filling.



*Conditions for a valid card:
Must be a valid card ID,
FAN will have been printed for the card.
The card will have been registered as Loading Card & Card must not be expired.


2
LRC will command PLC to open entry gate.
TT proceeds to the assigned Bay.
Is Bay Free?
No
Queued. Wait until assigned bay is free.
Yes
Wait until another card is issued.
Show "No Order for this Card".
Show "Please Show Card" And RIT Red Lamp Steady, Yellow Lamp Off, Green Lamp Off in RIT
TTES operator re-authorizes the card.
No
Is card valid for other bay?
Yes
No
Is Card Valid?
Show "Card No Longer Authorized".
Yes
Yes
Is card expired?
Show "Proceed to Bay No X". TT Driver Proceeds to Correct Bay as Printed on FAN.
No
TT No. Shown on Both Bay BC.
Wait for valid card
3


3
No
Multi product Bay?
Yes
Is TT authorized to load both products simultaneously?
No
Show "Not in Use" In one bay BC
Yes
Driver prepares loading.
Is Earthing done?
No
Prompt driver to connect Earthing clip. "CONNECT GROUND" message on BC Set RIT lamp red.
Yes
Is loading arm In Position?
No
Prompt driver to position the loading Arm. "ARM NOT IN POSITION" Message on BC. Set RIT lamp red.
Yes
Display Comp No, Quantity and "PRESS ACK"on BC advising the driver to press Amber push button on RIT.
Is ACK" button pressed?
No
Yes
C
4

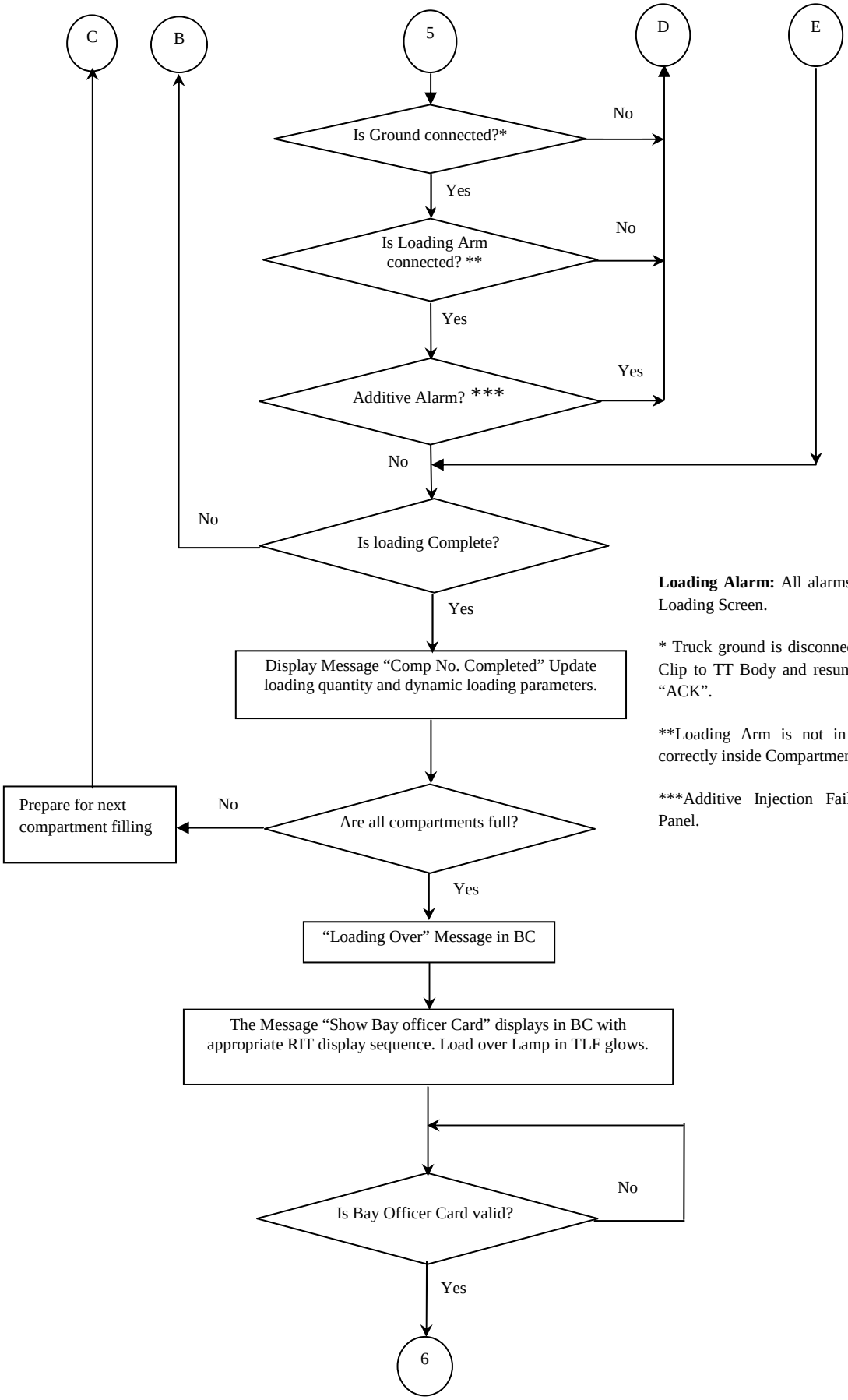


Loading Alarm: All alarms are displayed on Bay Loading Screen.

* Low/High Flow Alarm occurs due to Pump/Valve malfunctioning. Check Pump/valves in line and resume loading By pressing “ACK”.

**Restore Local Stop from RIT.

***Acknowledge ESD from Control Room.

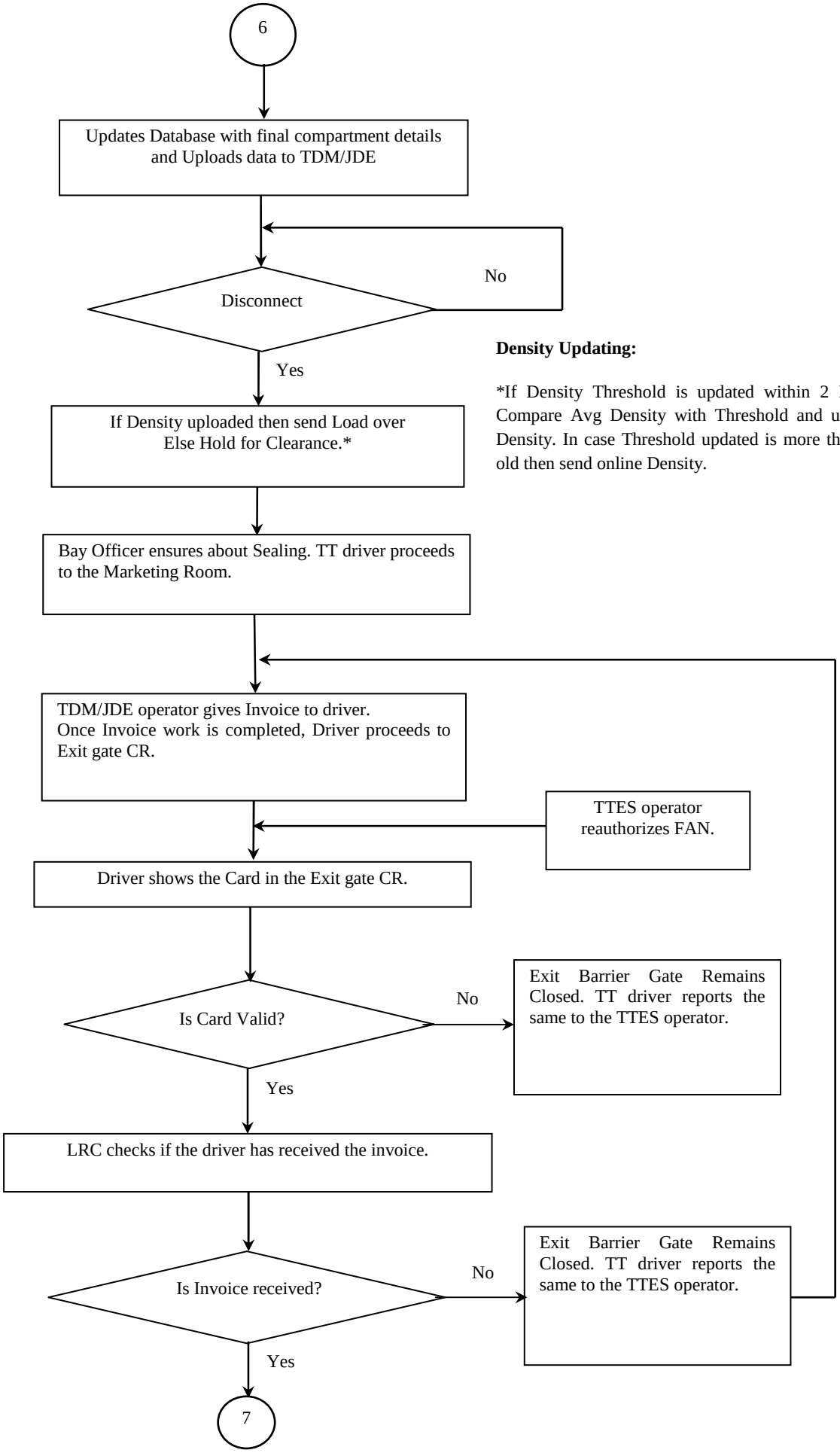


Loading Alarm: All alarms are displayed on Bay Loading Screen.

* Truck ground is disconnected. Connect Earthing Clip to TT Body and resume loading by pressing “ACK”.

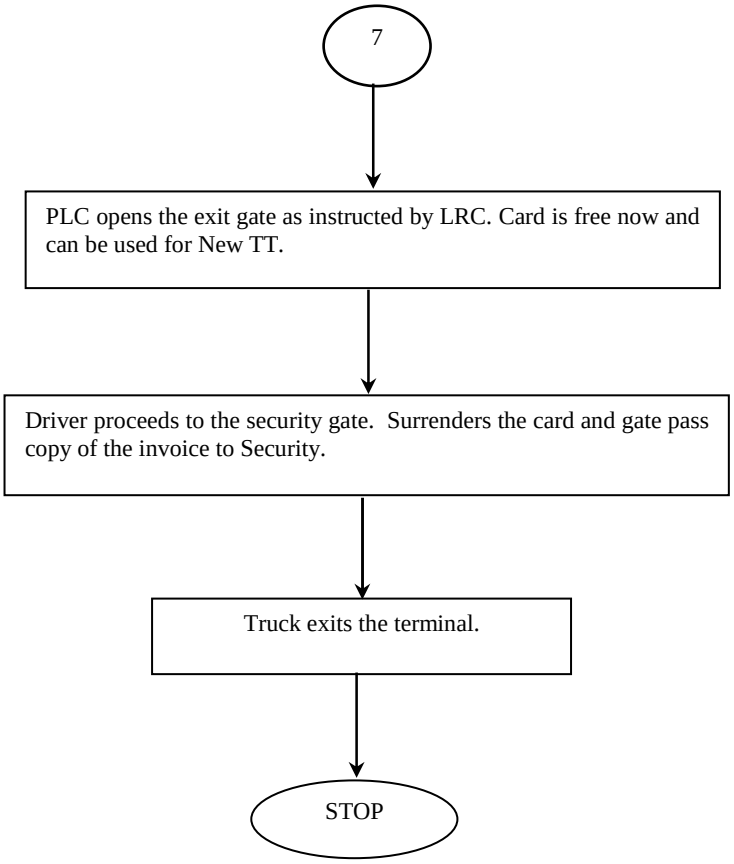
**Loading Arm is not in Position. Insert Arm correctly inside Compartment.

***Additive Injection Failure. Check Additive Panel.



Density Updating:

*If Density Threshold is updated within 2 Hours then Compare Avg Density with Threshold and update valid Density. In case Threshold updated is more than 2 Hours old then send online Density.



The total product of all the above is terminal automation system. This system is efficient, accurate, reliable and cost effective also. If we include the new developments in the automation field in TAS we will get more accurate and safer system. We can expect a completely automated, 100% safer system in future.

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