

Product Quality in Light Product Storage and Handling Operations

API RECOMMENDED PRACTICE 1640
SECOND EDITION, FEBRUARY 2021



American
Petroleum
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Product Quality in Light Product Storage and Handling Operations

1 General

1.1 Scope and Purpose

This recommended practice (RP) is intended to provide guidance on the minimum equipment standards and operating procedures for the receipt, storage blending and delivery of non-aviation light products, their blend components, and additives at distribution and intermediate storage terminals, including related operations of pipeline, marine vessel (barge or ship) and road and rail transport.

This publication recognizes the variety of conditions and the means to address product quality. Thus, this publication is intended to provide recommended practices, rather than set rigid guidelines. However, to demonstrate that site has addressed variances to the recommended practices, a documented risk assessment shall be created. It is up to the organization what form the risk assessment may take.

Users of this publication should be aware that due consideration shall be given to the effect of any unusual or abnormal circumstance on which it is not possible to generalize within the scope of this publication. Specialist advice shall be sought in these cases.

This publication should assist those involved in fuel handling at distribution and intermediate storage facilities. Every effort has been made by API to assure the accuracy and reliability of the data contained in this publication; however, API makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any local or regional laws or regulations with which this publication may conflict.

This RP is intended to provide guidance on the minimum equipment standards and operating procedures for the receipt, storage, blending of light products, including but not limited to gasoline, kerosene, diesel, heating oil and their blend components (i.e. ethanol, biodiesel/FAME, and butane) at distribution and storage terminals, as well as light product shipments directly via a pipeline, marine vessel (barge or ship) or road and rail transport.

In addition, this RP provides guidance for the design, construction, operation and maintenance of light products storage and distribution terminals with the specific intent of protecting or ensuring product quality.

This document incorporates by reference several other standards and recommended practices. The distinction between mandatory, recommended, and optional provisions in the referenced documents is not changed by nature of their reference in this standard.

The values stated in this RP are International Units (SI); U.S. Customary (USC) units are in parentheses.

1.2 Non-applicability

This document is not intended to cover fuels addressed in other applicable documents (i.e. aviation fuels) covered under API 1595 or EI/JIG Standard 1530.

This RP does not cover intermediate or residual fuels (i.e. bunker fuels, #4 oils and #6 oils).

The design and construction provisions of this standard are intended for application at new facilities. Application of the design and construction provisions of this standard to facilities, equipment, structures, or installations that are already in place, that are in the process of construction or that are installed before the date of this publication should be evaluated when circumstances merit. Such an evaluation should consider the site-specific circumstances and detailed accounting for both the potential and tolerance for risk, existing conditions at the installation, and overall benefit for applying the required design and construction provisions.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API *Manual of Petroleum Measurement Standards (MPMS) Chapter 8.1, Manual Sampling of Petroleum and Petroleum Products*

API MPMS Chapter 8.2, *Standard Practice for Automatic Sampling of Petroleum and Petroleum Product*

API MPMS Chapter 11.1, *Physical Properties Data Section—Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubrication Oils*

API MPMS Chapter 11.3.3, *Ethanol Density and Volume Correction Factor Tables*

API Bulletin 939-E, *Identification, Repair, and Mitigation of Cracking of Steel Equipment in Fuel Ethanol Service*

API Recommended Practice 652, *Linings of Aboveground Petroleum Storage Tank Bottoms*

API Recommended Practice 1626, *Storing and Handling Ethanol and Gasoline-ethanol Blends at Distribution Terminals and Filling Stations*

API Recommended Practice 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

API Standard 653, *Tank Inspection, Repair, Alteration, and Reconstruction*

API Standard 2610, *Design, Construction, Operation, Maintenance, and Inspection of Terminal and Tank Facilities*

ASTM D975, *Standard Specification for Diesel Fuel*

ASTM D1265, *Standard Practice for Sampling Liquefied Petroleum (LP) Gases, Manual Method*

ASTM D1835,¹ *Standard Specification for Liquefied Petroleum (LP) Gases*

ASTM D3244, *Standard Practice for Utilization of Test Data to Determine Conformance with Specifications*

ASTM D4057, *Standard Practice for Manual Sampling of Petroleum and Petroleum Products*

ASTM D4177, *Standard Practice for Automatic Sampling of Petroleum and Petroleum Products*

ASTM D4057, *Standard Practice for Manual Sampling of Petroleum and Petroleum Products*

ASTM D4362, *Standard Specification for Propane Thermophysical Property Tables*

ASTM D4650, *Standard Specification for Normal Butane Thermophysical Property Tables*

ASTM D4806, *Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel*

ASTM D5842, *Standard Practice for Sampling and Handling of Fuels for Volatility Measurement*

ASTM D5854, *Standard Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products*

¹ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

ASTM D6751, *Standard Specification for Biodiesel/FAME Fuel Blend Stock (B100) for Middle Distillate Fuels*

ASTM D6469, *Standard Guide for Microbial Contamination in Fuels and Fuel Systems*

ASTM D7464, *Standard Practice for Manual Sampling of Liquid Fuels, Associated Materials and Fuel System Components for Microbiological Testing*

ASTM Manual 47, *Fuel and Fuel System Microbiology: Fundamentals, Diagnosis, and Contamination Control*

Concawe², Report No. 9/09, *Guidelines for handling and blending biodiesel/FAME*

ISO 4259,³ *Petroleum Products — Determination and Application of Precision Data in Relation to Methods of Test EI Guidelines*⁴

ISO3170, *Petroleum liquids — Manual sampling*

ISO3171, *Petroleum Liquids — Automatic Pipeline Sampling*

U.S. Code of Federal Regulations, *Title 40: Protection of the Environment*⁵

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

biodiesel/FAME

A fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100, and meeting the requirements of ASTM D6751 or EN 14214 in Europe, see FAME.

NOTE Biodiesel/FAME is a renewable fuel for diesel engines. Made from agricultural co-products and byproducts such as soybean oil, other natural oils, and greases. To be called biodiesel/FAME, it must meet the strict quality specifications of ASTM D6751 or EN 14214 in Europe. Biodiesel/FAME can be used in any blend with petroleum diesel fuel according to the maximum limit allowable in the specification.

3.1.2

biodiesel/FAME blend

A blend of biodiesel/FAME fuel with diesel fuel oils, designated BXX, where XX represents the volume percentage of biodiesel/FAME fuel in the blend.

3.1.3

blending into isolated tank

Blending such that the entire resulting tank is certified prior to release—where product is not moving directly into the conveyance so there is opportunity to analyze and correct prior to product being released. This includes batch mixing of components either inline or in tank, and online analytical control of the blend.

3.1.4

certificate of analysis

The document that contains the test results and declarations that comprise the certification of the product. Also called the Certificate of Quality in some locations.

² Concawe, Boulevard du Souverain 165, B-1160 Brussels, Belgium, www.concawe.eu.

³ International Organization for Standardization, 1, Chapter de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.

⁴ Energy Institute, 61 New Cavendish Street London W1G 7AR, U.K., www.energyinst.org.

⁵ The Code of Federal Regulations is available from the U.S. Government Printing Office, Washington, DC 20402.

3.1.5**certification**

Declaration that the product meets specified requirements for product representation. The declaration is to be accurate and complete, conforming to regulatory, contractual and company policy requirements and traceable to a specific batch or volume of product.

3.1.6**corrective action**

Corrective actions are improvements to an organization's processes taken to eliminate causes of non-conformities or other undesirable situations.

3.1.7**dedicated pipeline**

A pipeline that is only used to handle one grade of fuel.

3.1.8**dedication**

Refers to dedicated hardware, vessels and/or facilities such as pipelines, piping, tankage, and filters that are used to handle only one grade of fuel or component.

3.1.9**drop tube**

Refers to part of the loading arm used in the loading operation for road and rail cars.

3.1.10**fatty acid methyl ester (FAME)**

Is the generic chemical term for biodiesel/FAME derived from renewable sources. The biodiesel/FAME manufacturing process converts oils and fats into chemicals referred to as fatty acid methyl esters and the process is referred to as transesterification. See biodiesel/FAME.

3.1.11**fit for purpose/fit for use**

Meet or exceed equipment requirements and reasonable consumer needs.

3.1.12**fungible batch**

A batch that may be mixed with one or more batches of product of the same grade and specification.

3.1.13**hydrophilic**

Having an affinity for water; readily absorbing or dissolving in water.

3.1.14**interface**

A volume of petroleum product generated in a pipeline between two adjacent volumes of non-identical petroleum product that consists of a mixture of the two adjacent products.

3.1.15**internal audit**

A systematic examination of a company's quality management system documentation and related activities by an internal or external team to determine conformance to the applicable quality management system standard developed to comply with API 1640.

3.1.16**isolation**

The act of creating a positive physical separation or barrier between products or components.

3.1.17**live (active) tank**

A tank that is actively receiving or delivering product.

3.1.18**parameter**

Used to describe an aspect of the product quality, a subset of the “total” specification for the product. For example: %vol benzene is one parameter of a motor gasoline specification. Octane is another.

3.1.19**piping**

A term used to describe pipework, valves and manifolds that are used to get product from a tank to a tank or conveyance (such as a pipeline, ship, barge, tank truck) or vice versa. Normally the characteristics of piping are:

- the tankage and piping are under the control of one site,
- the volume of each batch is greater than the volume of the piping (can expect a maximum of one interface in the piping at any one time, the definition for pipeline for more than one interface).

3.1.20**pipeline**

A pipeline can be considered to be a long tube, made up of one or many conduit sections that connects installations such as terminals, refineries, docks etc. that is used to transport light products and other fluids.

- The tankage, piping and pipeline are under the control of more than one site.
- The volume of the pipeline is large (can expect more than one interface in the pipeline at any time).

3.1.21**procedures**

Procedures are documented work instructions that include scope, defined responsibility, task, frequency and reference standards.

3.1.22**product distribution**

Refers to the shipment of a product to various locations or customers.

3.1.23**product release**

Authorization to distribute products.

3.1.24**product transfer**

Refers to either the movement of product from one conveyance or vessel to another or change of title or custody.

3.1.25**product waiver**

Product waiver is an authorized release, following full consideration of acceptable business and customer risks, of a product not meeting specification. Product waivers are limited in time, parameter, volume, and geography.

3.1.26**product quality event**

All unplanned product quality variations (for those products and blendstocks covered within this RP) and actions that do not meet the expectations of this RP. This includes customer complaints, product waivers and product quality incidents.

3.1.27**product quality incident**

An incident is when product is non-conforming with either specification, fit-for-use, regulatory compliance, or company policy and has passed a “perimeter” (site boundary or point of custody transfer), whether that perimeter is between an entity and a third party or between internal businesses.

3.1.28**renewable hydrotreated diesel****RHD**

In the U.S.—A fuel derived from 100 % hydrotreated bio-mass feedstocks that meets the registration requirements for fuels and fuel additives established by the Environmental Protection Agency (EPA) under Section 211 of the Clean Air Act and the ASTM D975 specification.

In Europe—A renewable hydrotreated diesel is a paraffinic fuel derived from synthesis or hydrotreatment processes using bio-mass feedstocks. Paraffinic fuels are produced using different technologies and include Hydrotreated Vegetable Oil (HVO), Gas-to-Liquids (GTL) and Biomass-to-Liquid (BTL). Paraffinic diesel quality in Europe is defined by the EN 15940 specification, HVO and BTL, produced using bio-mass as feedstocks, are considered biofuels according to 2009/28/CE Renewable Energy Directive and Fuel Quality Directive 2009/30/CE.

3.1.29**risk**

Risk is the combination of the consequence and probability of failure mode scenarios.

3.1.30**risk assessment**

A documented evaluation of the likelihood and consequence of potential events that may negatively impact product quality.

3.1.31**running tank**

A running tank is defined as any tank that is receiving and delivering product simultaneously. [See live (active) tank.]

3.1.32**sample, all-levels**

A sample obtained by lowering the closed sampling device to the bottom of the outlet suction level, but always above free water, then opening the sampler and raising it at a uniform rate such that it is between 70 % and 85 % full when withdrawn from the product. Alternately, all levels samples may be taken with samplers designed for filling as they pass downward through the product.

3.1.33**sample, bottom**

A spot sample collected from the material at the bottom of the tank, container, or line at its lowest point. In practice, the term bottom sample has a variety of meanings. As a result, it is recommended that the exact sampling location [for example 15 cm (6 in.) from the bottom] should be specified when using this term (see Figure 1).

3.1.34**sample, bottom water**

A spot sample of free water taken from beneath the petroleum contained in a ship or barge compartment or a storage tank.

3.1.35**sample, dead bottom**

A sample obtained from the lowest accessible point in a tank. This is typically directly from the floor (or datum plate) of the shore tank or the bottom of the vessel compartment.

3.1.36**sample, lower**

A spot sample of liquid from the middle of the lower one third of the tank's content (a distance of $\frac{5}{6}$ of the depth liquid below the liquid's surface) (see Figure 1).

3.1.37**sample, middle**

A spot sample taken from the middle of a tank's contents (a distance of $\frac{1}{2}$ of the depth of liquid below the liquid's surface) (see Figure 1).

NOTE Taken from API *MPMS* Chapter 8.1, Standard Practice for Manual Sampling of Petroleum and Petroleum Products.

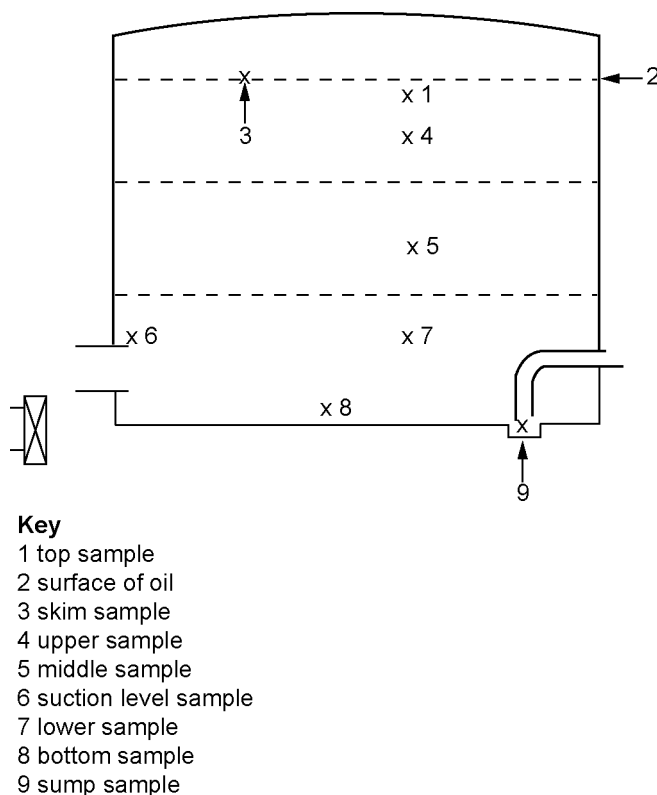


Figure 1—Illustration of Common Spot Sample Positions

3.1.38**sample, multiple tank composite**

A mixture of individual samples or composites of samples that have been obtained from several tanks or ship/barge compartments containing the same grade of material. The mixture is blended in proportion to the volume of material contained in the respective tanks or compartments.

3.1.39**sample, representative**

A portion extracted from the total volume that contains the constituents in the same proportions that are present in that total volume.

3.1.40**sample, running**

A sample obtained by lowering an open sampling device to the bottom of the outlet suction level, but always above free water, and returning it to the top of the product at a uniform rate such that the sampling device is between 70 % and 85 % full when withdrawn from the product.

3.1.41**sample, spot**

A sample taken at a specific location in a tank or from a flowing stream in a pipe at a specific time (see Table 1).

Table 1—Spot Sample Requirements

Liquid Level	Number of Samples		
	Upper	Middle	Lower
Liquid level ≤ 3 m (10 ft)		X	
Liquid level > 3 (10 ft) and ≤ 6 m (20 ft)	X		X
Liquid level > 6 m (20 ft)	X	X	X

3.1.42**sample, suction (outlet)**

A spot sample taken at the lowest level from which product is expected to be pumped from the tank (see Figure 1).

3.1.43**sample, sump**

A spot sample taken from within the tank or vessel compartment sump.

3.1.44**sample, surface (skim sample)**

A spot sample skimmed from the surface of a liquid in a tank.

3.1.45**sample, tank composite**

A blend created from a single tank, as an example combining the upper, middle, and lowers samples. For a tank of uniform cross section, such as an upright cylindrical tank, the blend consists of equal parts of the three samples. A combination of other samples may also be used, such as running, all-levels or additional spot samples. For a horizontal cylindrical tank, the blend consists of samples in the proportions shown in Table 2.

Table 2—Tap Sampling Requirements

Tank Capacity/Liquid Level	Sampling Requirements
Tank capacity less than or equal to 1590 m ³ (10,000 bbls)	
Level below middle tap	Total sample from the lower tap
Level above middle tap-level closer to middle tap	Equal amounts from the middle and lower taps
Level above middle tap-level closer to upper tap	$\frac{2}{3}$ of total sample from the middle tap and $\frac{1}{3}$ of total sample from the lower tap
Level above upper tap	Equal amounts from the upper, middle, and lower taps
Tank capacity of greater than 1590 m ³ (10,000 bbls)	Obtain samples at listed in Table 1. If liquid level and taps available do not allow the proper number of samples to be obtained, additional manual samples are to be obtained, such as open hatch sampling from the top of the tank.

3.1.46**sample, top**

A spot sample obtained 15 cm (6 in.) below the top surface of the liquid (see Figure 1).

3.1.47**sample, upper**

A spot sample taken from the middle of the upper $\frac{1}{3}$ of the tank's contents (a distance of $\frac{1}{6}$ of the liquid depth below the liquid's surface) (see Figure 1).

3.1.48**sample, volumetric composite**

A sample consisting of measured proportional parts from each zone if it is for a single tank. If the volumetric composite is for multiple tanks, or vessel compartments, it consists of measured proportional parts from each tank or compartment sampled.

3.1.49**sample, zone**

A sample taken as that part of the liquid column that is trapped within the whole height of a sampling device when it is sealed at a single spot location within a tank after having been fully flushed as it was lowered to that position.

3.1.50**sampling**

All the steps required to obtain a sample that is representative of the contents of any pipe, tank, or other vessel and to place that sample in a container from which a representative test specimen can be taken for analysis.

3.1.51**segregated loading system**

Piping from the shipping tank to loading flange, that is exclusive to product being loaded, with no connections that could introduce a possibility of cross-contamination.

3.1.52**segregated pipeline receipt**

A batch of product that is not fungible, which is individually identified and has unique characteristics requiring special handling.

3.1.53**segregation**

Segregation refers to provisions made such that products are positively isolated for quality control.

3.1.54**separation**

The act of isolating distinct product or batches.

3.1.55**sequential blending**

A blend method in which each component flows through its own meter and control valve separately and then into the common line. The two products flow sequentially one after the other, not simultaneously.

3.1.56**splash blending**

A type of blending accomplished by metering each blend component into a tank truck separately by using different loading arms. The loading arms are changed manually by the truck driver or operator. In some cases, the components may be loaded into compartments at different locations. There is no automatic checking of the validity of the finished product blend.

3.1.57**transmix**

A blend of fuels and/or components that does not meet the specifications for a fuel that can be used or sold and is composed solely of any combination of previously certified gasoline (including previously certified gasoline blendstocks that become gasoline solely upon the addition of an oxygenate), distillate fuel; or gasoline blendstocks that are suitable for use as a blend stock without further processing.

3.1.58**wild-stream blending**

Wild-stream blending is normally off rack blending of two products that supplies a blended product to the loading rack, one product uses a meter and a control valve and the second flows by demand or wild. The finished blend flows through a custody transfer meter and control valve downstream at the loading rack.

3.2 Acronyms and Abbreviations

API	American Petroleum Institute
ASTM	American Society for Testing Materials
BoL	bill-of-lading
CEN	European Committee for Standardization
CIRIA	Construction Industry Research and Information Association
CLP	Classification, Labeling and Packaging Regulation used in the European Union (EU) to ensure the protection of health and the environment to allow the free movement of substances, mixtures, and articles.
CoA	certificate of analysis
DEF	diesel exhaust fluid
EPA	Environmental Protection Agency
EEMUA	The Engineering Equipment and Materials Users Association
EI	Energy Institute
EU	European Union
FSII	fuel system icing inhibitor
ISO	International Organization for Standardization
MOC	management of change
QMS	quality management systems
OSHA	Occupational Safety and Health Administration
PTD	product transfer documentation
RVP	Reid vapor pressure
SOP	standard operating procedure
UN	United Nations. UN Labels are used to alert people to hazardous materials and substances during transportation.
VAR	volumetric additive reconciliation

4 Quality Assurance System Health, Safety, Security, and Environment

Guidance can be found in API 2610 for the following procedures:

- health and safety permit to work system;
- security;
- protecting the environment;
- drainage; and

- maintaining the integrity of fuel tanks and systems.

4.1 Management Responsibility and Accountability

The management of storage and distribution terminals is responsible for ensuring that the facility design and operation conform to acceptable industry standards and the applicable legislative regulations with respect to health, safety, environmental protection, and security are applied.

The operating procedures for storage and distribution terminals shall be maintained in a manual or handbook or other media that is readily available for reference by staff. It is recommended that conformance to agreed-upon procedures be tied into a quality assurance system like the one outlined below.

Management at all levels shall provide a process for the early identification and mitigation of changes or upsets in the production, supply chain, or the final product use, that may result in product quality issues.

4.2 Quality Assurance Components

4.2.1 General

The potential commercial, consumer, and regulatory consequences of a failure to supply the correct, fit-for-use, on-specification products are such that it is essential for each organization to have an effective quality assurance system that shall be designed to ensure the following:

- expectations are communicated to all personnel who can have an impact on product quality;
- products are designed and specified to both comply with applicable regulations and be fit for purpose;
- product quality performance is evaluated and the degree to which expectations and customer requirements are met is assessed;
- clear objectives are set that demonstrate leadership and promote commitment to improving product quality performance through active and visible participation;
- employees at all levels accept responsibility for effective product quality controls, and early identification of potential customer problems;
- suppliers and contractors that can impact product quality are involved in maintaining and improving product quality performance;
- there are seamless and visible product quality improvement work processes;
- appropriate facilities and equipment for the safe and uncontaminated delivery of light products through the supply chain and ultimately to the point of custody transfer are provided and maintained; and
- there is an auditable documentary record demonstrating the correct handling, storage, blending and delivery of product at the intermediate and distribution terminal.

4.2.2 Product Quality Assurance Organization

4.2.2.1 General

The company shall have individuals nominated to carry out the following quality assurance responsibilities for each terminal. The specific details and execution of such responsibilities may vary according to the nature of the operating unit. Records shall be kept of the responsible individuals as well as the details of their experience and training received.

4.2.2.2 Site Product Quality Manager

For each site, there shall be an individual designated to fill the role of the site product quality manager. This person shall be responsible for the efficient operation of the quality assurance system at that site. At intermediate storage and distribution terminals, this role is usually taken by the terminal manager or supervisor (or operations manager of a large facility).

The site product quality manager shall be accountable for:

- implementation of correct quality control procedures;
- maintenance of satisfactory documentation;
- release of product only of satisfactory quality; and
- training of all staff at the site who are designated as Product Quality Inspectors.

4.2.2.4 Product Quality Inspectors

All staff whose duties include tasks critical to the quality assurance system shall be fully trained in such tasks and designated to fill the role of product quality inspectors. This role is usually taken by the terminal operator(s). Such tasks may be performed on-site or remotely and include, but may not be limited to the following:

- checking that the documentation on incoming consignments is correct and that it corresponds to the transport or container concerned;
- visually inspecting and conducting control checks and online sampling from pipelines and dock lines on incoming and outgoing material, including checking seals on vehicles (if present);
- product receipt into storage and post receipt testing;
- loading of material on marine vessels, road or rail transports, containers, and pipelines; and
- maintaining appropriate records of inventory, quality, and equipment checks.

4.2.2.5 Internal Audit

Documented internal product quality audits should be conducted at a regular frequency and should include a documented process/procedure to identify gaps, assign actions, and track gaps to closure with follow-up to determine efficacy of completed actions.

Some “in-scope” elements for consideration regarding internal product quality audits may include the review of the following components/items:

- Quality Management Systems (QMS);
- relevant work procedures Standard Operating Procedures (SOPs) etc.;
- inventory/loss control records and procedures;
- routine maintenance and inspection programs;
- sampling requirements, including documented procedures, storage, labeling, and retention times;
- product receipt and handling procedures, including additives;
- blending operations, as applicable;

- testing procedures;
- training procedures and documentation;
- conduct audit using all or parts of API 1640 checklist or customer supplied checklists, or a combination thereof.
- a documented procedure to define responsibilities for planning, conducting, and documenting internal audits.
- results of previous audits and criticality of the process being audited; and
- outsourced/subcontracted activities that impact the quality of the product and that are performed at the organization's facility being included as part of the internal audit of the organization such as:
 - Calibration of test equipment;
 - Meter calibration;
 - Analysis/testing by third party laboratories
 - Maintenance of additive injection systems; and
 - Tanks maintenance/ inspection.

Relevant records of audits conducted against all or parts of API 1640 using a relevant checklist (customer supplied or internal) shall be available.

NOTE The above suggestions have been provided as a guide; there may be other areas that an internal audit should consider based on the operational nature of the facility.

4.3 Training

Personnel shall be fully trained to undertake all planned quality control tasks, understand consequences and be able to respond adequately to unplanned events affecting product quality.

Common elements of a training program shall ensure that:

- training requirements for each job position are identified;
- individual needs are assessed against the identified job requirements;
- there is a documented training plan to close the identified training gaps;
- training programs linked to operating procedures are implemented according to the plan and regularly updated;
- evaluation of the competency of the individual after training is completed;
- testing and evaluation methodologies are used to document effectiveness of training programs (materials, methods, and content) and counter any weaknesses by improving the programs;
- individual needs are assessed at specified intervals and refresher training performed as needed;
- training records are kept for all identified individuals; and
- change management procedures are in place which identify changes in tasks or the scope of a job or individual responsibilities to allow the necessary additional training to be identified and implemented.

4.4 Risk Assessments

The organization shall maintain a documented procedure to identify and control risk associated with impact on receipt, storage and delivery operations, and quality of product. A risk assessment should be conducted every three years.

This is particularly important for:

- any newly constructed terminal;
- the resumption of operations after modification of piping, tankage, valves, and filters;
- introduction of new products;
- change of tank product service;
- aging infrastructure; and
- change in terminal ownership.

The risk assessment should consider:

- any previous product quality audit, assessment, or review of the facility;
- any history of incidents at the facility or with product from the facility;
- the terminal procedures for receipt testing (abbreviated testing) and additive reconciliation;
- if blending operations are performed;
- if the operation using pipelines is discharging to working tanks (live to the rack); and
- contract volume and service of products (i.e. consider the business impact if the product is not fit for service).
- A risk assessment may be a standalone document or integrated with documents such as procedures, training manuals or Management of Changes (MOCs).

For changes that have the potential to impact product quality, an MOC process should be used. An MOC process should describe accepted methods for initiating and managing change to ensure that all not-in-kind process changes are properly identified and controlled prior to implementation. A product quality MOC shall include procedures to ensure testing or other means of validation are considered. Examples of changes where an MOC process should be used include, but are not limited to:

- blend recipe changes,
- additive changes,
- new product introduction,
- hardware and software changes, and
- basic logistic changes (i.e. product source changes, receipt or delivery mode changes and tank change of service).

4.5 Incident Management

4.5.1 General

It is the goal of incident management to:

- identify events where there is a deviation from the expected product quality;
- manage or mitigate the impact;
- learn from the incident; and
- share within your organization what has been learned to prevent future incidents.

4.5.2 Incident Management Procedures

There shall be written procedures for the management of:

- product quality incidents;
- customer complaints;
- regulatory inquiries or violations; and
- other events which can impact product quality.

4.5.3 Initial Response

There shall be a defined responsible party or group and communication plan to manage product quality incidents with designated out-of-hours backups. The goal of the initial response should be to verify the incident, determine the scope, and minimize further impact of the incident.

4.5.4 Communication

Once the incident is verified, the concerned and affected parties shall be notified as soon as possible so additional mitigation steps may be taken.

4.5.5 Investigation

An assessment of the incident shall be performed, and management shall be notified. A product quality incident investigation shall be initiated with an investigation owner.

There shall be documented procedures for product quality complaints and incidents that ensure timely and regular stakeholder communication.

There shall be documented procedures in place and followed to ensure that all incidents are recorded and investigated in a timely manner.

The investigation shall address the failure mode(s), contributing factors, root causes and corrective actions.

4.5.6 Corrective Actions

The investigation process shall result in corrective actions that address each of the failure modes, contributing factors and root causes. Each corrective action shall include responsible personnel, implementation dates, and verification of sustainability and effectiveness.

4.5.7 Post Incident Reporting

For ongoing learning, summaries of product quality investigations, including an assessment of the business impact, shall be circulated according to predetermined guidelines.

5 Storage Terminals—Equipment Design

5.1 General

The observance of certain fundamental practices in the design, construction and commissioning of facilities used for the storage, handling and transport of fuels, components and additives is considered essential to ensure that product quality is maintained.

5.1.1 Segregation of Fuels and Components

All facilities used for handling fuels and components shall be product and grade-segregated unless each product and component is monitored and controlled, and then only provided the system is so designed to facilitate the detection and appropriate downgrading of product interfaces (see 5.3 and 9.2).

5.1.2 Materials of Construction

The materials of construction for the pipework, vessels, and tanks for light product storage and handling shall be in conformance with appropriate API, CEN, CIRIA and EEMUA standards, other industry standards, specifications, and recommended practices.

The choice of construction materials and equipment components is an important factor, particularly when new or novel blend components are being introduced.

Particular attention should be paid to issues (i.e. elastomer compatibility, sulfate deposition, pitting, corrosion and stress fractures) associated with the use of some biofuels.

Changes in fuel composition have been shown to cause some seal material degradation.

Some dyes have corrosive components that may result in accelerated corrosion in dye storage tanks.

5.1.2.1 Ethanol Compatibility

As stated in API 1626, before handling, storing and dispensing gasoline-ethanol blends, consideration should be given to the design and compatibilities of all components coming in contact with the blended liquid and vapors. Blend properties that should be considered include, stress corrosion cracking of steel structures, the flammability of vapors, vapor pressure, the hydrophilic nature of ethanol, the differential solvency of ethanol (i.e. the impact on polymeric materials: swelling, extraction, permeation, and embrittlement) and the water tolerance of ethanol blends. When a new blend is introduced, evaluate these properties for every step in the supply chain to assure product quality and safe handling and storage.

Compared with gasoline and hydrocarbon fuels in general, ethanol has a high electrical conductivity and oxygen content. The chemical properties of ethanol also contribute to its ability to readily absorb water. The suspension of water within gasoline-ethanol blends enhances galvanic corrosion and rusting by providing an oxygen-rich environment that is also a good conductor of electricity. These conditions present in ethanol blend service can lead to corrosion and ultimately metal loss of various components which are not normally adversely affected by gasoline.

Ethanol is not compatible with some grades of soft metals (i.e. zinc, brass, copper, lead, and aluminum). These metals may degrade or corrode in contact with ethanol and possibly cause a component failure or affect fuel quality. Seals, gaskets, and other elastomers that are not specifically intended for use with ethanol blends can

lose their integrity leading to a product leak. Before using any component in ethanol service, verify its compatibility with the manufacturer.

Concawe Report No. 3/08 includes additional recommendations for containment. Considering fuel distribution system (not the fuel system components commonly used on vehicles), Table 3 shows recommendations for materials that should be considered for use in ethanol and ethanol/gasoline blends applications.

Table 3—Material Compatibilities with Ethanol and Ethanol/Gasoline Blends

Material	Recommended	Not Recommended
Metals	— Carbon steel with post-weld heat treatment of carbon steel piping and internal lining of carbon steel tanks — Stainless steel — Bronze — Aluminum	— Zinc and galvanized materials — Brass — Copper — Lead/tin-coated steel — Aluminum (many be an issue for E100)
Elastomers	— Buna-N (hoses and gaskets) — Fluorel — Flurosilicone — Neoprene (hoses and gaskets) — Polysulfide rubber — Viton	— Buna-N (seals only) — Neoprene (seals only) — Urethane rubber — Acrylonitrile-butadiene hoses — Polybutene terephthalate
Polymers	— Acetal — Polypropylene — Polyethylene — Teflon — Fiberglass-reinforced plastic	— Polyurethane — Polymers containing alcohol groups (such as alcohol-based pipe dope) — Nylon 66 — Fiberglass-reinforced polyester and epoxy resins — Shellac
Others	— Paper — Leather	— Cork
^a See Reference [2] in bibliography.		

This list is not comprehensive, and the quality of the material must be appropriate for the intended application. It is strongly advised that the manufacturers of these products are consulted before ethanol or ethanol/gasoline blends are introduced. The Concawe report includes additional recommendations and details for containment system (around tank and loading racks); for tanks, pipe sealants, meters, hoses used for E5 or E100; for fuel filters, nozzles for E5; and for pumps used for E100.

Denaturants and sulfate issues should be considered, and they are limited on ethanol and gasoline specifications, such as ASTM D4806 or EN228, to ensure an appropriate handling of ethanol and ethanol blends.

More detailed information on materials compatibility can be found in Concawe Report No. 3/08. Flow meter and pump deposits as well as filter plugging and injector sticking incidents in vehicles have been reported in the U.S. after they were exposed to some ethanol/gasoline blends. According to work reported by ASTM, insoluble sulfates have been implicated in these deposits and are believed to originate from sulfates carried over from the ethanol manufacturing process. Specifications for fuel grade ethanol should ensure against manufacturing impurities, including insoluble sulfates. Customs and Excise agencies use denaturants to prevent the ingestion of ethanol that is not intended for human consumption. Because there is evidence that some denaturants can impact engine operation and performance, only denaturants that have been demonstrated to have no detrimental effect on engine performance should be used where they are allowed.

5.1.2.2 Biodiesel/FAME Compatibility ⁶

Existing supply and distribution facilities designed for use with hydrocarbon-only diesel fuels should in general be adequate for handling diesel fuels containing biodiesel/FAME. It is recommended to review the need for hardware modifications throughout the supply chain with consideration of potential material incompatibilities and the increased risk of deposit formation. The following points should be specifically considered:

- dedicated lines may be needed for receipts and deliveries (at terminals) to avoid water and other contamination;
- gaskets should be compatible with biodiesel/FAME, including those fitted in flanges and swivel joints;
- lagged or heat traced pipelines may be appropriate depending on the ambient temperatures and the cold flow properties of the diesel blend; and
- the design of product filters should be considered as well as the frequency of change out.

It is important to recognize that biodiesel/FAME is chemically different from fuel hydrocarbons due to its chemical functionality. Because of this chemical difference, various components in the fuel distribution system may be less compatible with biodiesel/FAME than they are with hydrocarbon-only fuels. Sensitive materials may swell or lose their integrity after prolonged contact with biodiesel/FAME. They may even promote fuel degradation reactions due to their chemical composition.

Biodiesel/FAME may degrade some hoses, gaskets, seals, elastomers, glues, and plastics after prolonged exposure. Biodiesel/FAME may also permeate some types of plastics (polyethylene, polypropylene) over time and they are not recommended for use in storing biodiesel/FAME. Natural or nitrile rubber compounds, polypropylene, polyvinyl, and plasticized PVC tubing materials are particularly sensitive. Polytetrafluoroethylene, fluoroelastomers or synthetic rubber materials, and Nylon are not sensitive to biodiesel/FAME and are among the materials that can be used to update incompatible materials in equipment.

Most tanks that are designed to store diesel fuel should also be adequate for storing biodiesel/FAME. Acceptable storage tank materials include aluminum, steel, fluorinated polyethylene, fluorinated polypropylene, polytetrafluoroethylene, and most fiberglass products.

Brass, bronze, copper, lead, tin, and zinc may catalyze the oxidation of biodiesel/FAME accelerating the formation of insoluble gels and salts. Lead solders and zinc linings should be avoided, as should copper pipes, brass regulators, and copper fittings. Affected equipment should be replaced with stainless steel, carbon steel or aluminum.

Table 4 provides an overview of materials that are either recommended for use or should be avoided when handling biodiesel/FAME. This list is not comprehensive, and the quality of the material must be appropriate for the intended application. Suppliers of biodiesel/FAME products and equipment vendors should be consulted regarding the most recent findings on material compatibility for bio-component applications.

In general, diesel fuels containing much lower biodiesel/FAME concentrations should have a much smaller effect on materials used in the fuel distribution system. At 10 % v/v biodiesel/FAME or lower concentrations, the effects are not likely to be appreciable although some sensitivity of nitrile rubbers has been reported. Although this is the case with fuel system materials, the metals indicated in Table 4 should still be avoided, even for diesel fuel blends to minimize the potential for metal pick-up.

⁶ This section used by permission from the Concawe guidelines for handling and blending biodiesel.