

# **An Asset Management Approach for EPA/CARB SF<sub>6</sub> Regulations**

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## **Paper Abstract**

Starting in 2011, the State of California, through the California Air Resources Board (CARB), became the first state to enact mandatory reductions in SF<sub>6</sub> emissions. Over the last ten years, Southern California Edison's (SCE) participation in the US Environmental Protection Agency's (EPA) Voluntary SF<sub>6</sub> Emission Reduction Partnership for Electric Power Systems has yielded reduced SF<sub>6</sub> emissions. Nonetheless, the more stringent regulations and related data requirements from CARB presented new challenges for gas-insulated switchgear owners. To address these challenges involving increased inventory and data management, our existing program had to evolve. Therefore, SCE transitioned the (mostly) paper documentation process to an electronic process involving our company-wide asset management system and an in-house-developed field tool to ensure compliance with the more rigorous CARB SF<sub>6</sub> regulations.

This paper will present an overview of the tools and methods that SCE utilizes to track SF<sub>6</sub> gas in our service territory to meet EPA's and CARB's mandatory requirements. The paper process that was used for the EPA reporting will be detailed followed by the transition of this paper process to an electronic process able to meet both EPA and CARB reporting requirements. A "user experience" analysis is described demonstrating the overall "life" of a gas cylinder upon entering inventory and eventually leaving inventory, including its usage, data processing, and reporting to regulators. SF<sub>6</sub> Quality Assurance methods and related data analysis for reporting internally and externally will also be discussed. This paper is intended to be an approach for entities to model in an effort to aid them in meeting reporting requirements in an increasingly more stringent greenhouse gas regulatory climate.

Southern California Edison, an Edison International subsidiary, is one of the nation's largest investor-owned electric utilities, serving more than 14 million people in a 50,000 square-mile area of central, coastal and Southern California excluding the City of Los Angeles and certain other cities. Headquartered in Rosemead, California, the utility has been providing electric service in the region for more than 120 years.<sup>1</sup> In regards to SF<sub>6</sub> gas, SCE has approximately 800,000 pounds of SF<sub>6</sub> nameplate capacity as determined based on SF<sub>6</sub>-containing equipment in-service at the end of 2011.

SCE's SF<sub>6</sub> Gas Management Program was forced to evolve in a changing environmental regulatory landscape. The EPA introduced the Greenhouse Gas Reporting Program (GHGRP) in October 2009 via 40 C.F.R. Part 98. The Subpart DD component, which detailed requirements concerning SF<sub>6</sub> gas in electrical equipment, was not appended to the GHGRP until December 2010, with a mandatory reporting year set for 2011. Coincidentally, SF<sub>6</sub> regulation in the state of California (Cal. Code Regs., Tit. 17, Sections 95350 to 95359, administered by CARB), also became effective in 2011.

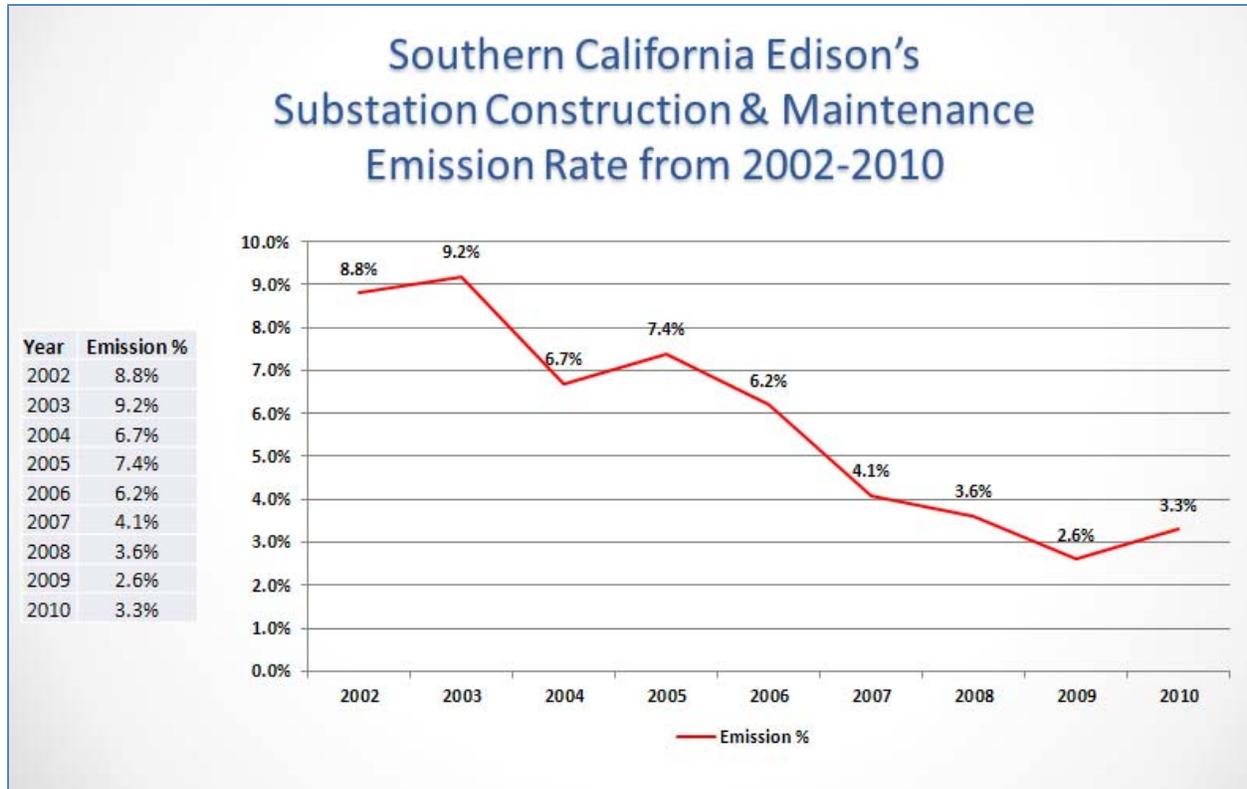
While SCE's SF<sub>6</sub> Gas Management Program was sufficient to be able to meet EPA's Voluntary SF<sub>6</sub> Emission Reduction Partnership program and current GHGRP, to meet the challenges of the 2011 CARB regulation, our existing paper-based program required modifications. California's regulation mandated emission reduction to 1% by 2020 in addition to more stringent elements not identified in the EPA GHGRP. Our program would need to comply with both EPA and CARB regulations. Therefore, SCE had to transition the paper documentation process to an electronic process involving our company-wide asset management system and an in-house-developed field tool to ensure compliance with the more rigorous CARB SF<sub>6</sub> regulations.

## Introduction

SCE has made great strides to become a leader in reducing SF<sub>6</sub> gas emissions. SCE has been involved in EPA's Voluntary SF<sub>6</sub> Emission Reduction Partnership for Electric Power Systems since 2001. However, SCE first established the SF<sub>6</sub> Gas Management Program in 1998. We are able to demonstrate an overall decrease in our emission rate by effectively managing, documenting, and controlling SF<sub>6</sub> inventories in equipment and in storage cylinders. Our three-part SF<sub>6</sub> Gas Management Program consists of: (1) tracking gas quantities in equipment (nameplate capacity); (2) managing purchases, inventories, and residual product; and (3) handling gas recycling for used or contaminated gas. Our program underwent a revision in 2006 followed by an additional and more dramatic revision in 2011. Environmental benefits have already been achieved due to emissions reduction, while the economic benefits of reduced resource allocation for maintaining leaking SF<sub>6</sub> equipment have been realized. Figure 1, which is shown below, displays emission rate data from the Substation Construction and Maintenance business line of SCE's Transmission and Distribution Business Unit. (It should be noted that other areas of SCE also contribute to SCE's overall emissions rate, including distribution systems and power production).

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<sup>1</sup> Edison International. Edison International: Our Company: Southern California Edison. Retrieved on April 7, 2012, from <http://www.edison.com/ourcompany/sce.asp>.



**Figure 1: SCE's Substation Construction & Maintenance Emission Rate Chart demonstrating SF<sub>6</sub> Emission Rate from 2002-2010**

The intent of this paper is to establish an approach for other entities to model to aid in meeting SF<sub>6</sub> reporting requirements. SCE has learned much from our original 1998 program to its recent revision to meet the more stringent CARB regulations. The hope is that we can share this information with other entities in our industry to facilitate their implementation of SF<sub>6</sub> measures to meet regulations. The paper process detailed may meet most entities' needs in relation to the EPA GHGRP. However, the additional amount of data required for CARB's regulation necessitated an electronic process to ensure that field crews would not be severely impacted.

This paper will focus on efforts to manage SF<sub>6</sub> gas in the Substation environment for SF<sub>6</sub>-insulated circuit breakers, switchers, and gas-insulated switchgear and the cylinders, gas carts, and any other containers that contain SF<sub>6</sub> gas. The content of the paper is as follows:

- An overview of the EPA and CARB requirements will be presented;
- The paper process that was used for EPA reporting will be detailed, followed by the evolution of this paper process to the electronic SF<sub>6</sub> Smart Form Tool;
- A "user experience" scenario is performed following a fictitious field crew's use of the SF<sub>6</sub> Smart Form Tool and the related processing of data to be utilized in regulatory reporting; and
- SF<sub>6</sub> Quality Assurance methods and related data analysis for reporting internally and externally will also be discussed.

While it would have been advantageous to include more screen shots of our SF<sub>6</sub> Smart Form Tool, this was not possible since the information could be considered Confidential Business Information. Therefore, to ensure SCE's confidentiality, much of the related information is presented in diagrams or text within the relevant section.

The audience for this paper is any electric utility entity that manages SF<sub>6</sub> gas and SF<sub>6</sub> equipment. While reporting to the regulatory agencies may be based on total nameplate capacity exceeding thresholds (EPA - 17,820 pounds of SF<sub>6</sub> gas; CARB - No exemption threshold exists) or other reasons, the concepts presented are useful in entities playing their part to reduce SF<sub>6</sub> gas emissions. This paper also applies to those entities on the cusp of exceeding the nameplate capacity thresholds, or those in states investigating the adoption of more stringent SF<sub>6</sub> regulations.

**This paper is based on the EPA and CARB Regulations as established for the 2011 Reporting Year.**

### **An Overview of EPA SF<sub>6</sub> Regulations and CARB SF<sub>6</sub> Regulations**

While this paper will not seek to explain every facet of the EPA and CARB regulations, it is prudent to underscore the major concepts and the differences between the State and the Federal regulations prior to understanding the program that must be able to meet these regulations.

Both EPA and CARB regulations utilize the mass-balance approach in determining annual GHG emissions. Reporting requirements within the *mass-balance equation*<sup>2</sup> are as follows:

**User Emissions = (Decrease in SF<sub>6</sub> Inventory) + (Acquisitions of SF<sub>6</sub>) – (Disbursements of SF<sub>6</sub>) – (Net increase in total nameplate capacity of active GIS equipment owned)**

**Where:**

- **Decrease in SF<sub>6</sub> Inventory** = (SF<sub>6</sub> stored in containers, but not in equipment, at the beginning of the year **[A]**) – (SF<sub>6</sub> stored in containers, but not in equipment, at the end of the year **[B]**)
- **Acquisitions of SF<sub>6</sub>**<sup>3</sup> = (SF<sub>6</sub> purchased in bulk from chemical producers, distributors, or other entities **[C]**) + (SF<sub>6</sub> purchased from equipment manufacturers, distributors, or other entities with or inside active GIS equipment **[D]**) + (SF<sub>6</sub> returned to site after off-site recycling **[E]**)
- **Disbursements of SF<sub>6</sub>** = (SF<sub>6</sub> in bulk and contained in active GIS equipment that is sold to other entities **[F]**) + (SF<sub>6</sub> returned to suppliers **[G]**) + (SF<sub>6</sub> sent off-site for recycling **[H]**) + (SF<sub>6</sub> sent to destruction facilities **[I]**)

<sup>2</sup> See Cal. Code Regs., tit. 17, § 95356 (d); and 40 C.F.R. 98.303.

<sup>3</sup> The definition of the phrase “acquisitions of SF<sub>6</sub>” in Equation DD-1 in 40 C.F.R. § 98.303 makes explicit that hermetically sealed assets are included in the calculation of SF<sub>6</sub> purchased from equipment manufacturers, distributors, or other entities with or inside active GIS equipment. California defines “hermetically sealed assets” as those designed to be gas-tight and sealed for life. This type of switchgear is pre-charged with SF<sub>6</sub>, sealed at the factory, and is not refillable by its user. See Cal. Code. Regs. tit. 17, § 95351 (a)(9). Hermetically sealed assets are not included within this item in the CARB regulation.

- **Net increase in total nameplate capacity of active GIS equipment owned<sup>4</sup>** = (The nameplate capacity of new active GIS equipment [J]) – (Nameplate capacity of retiring active GIS equipment [K])

The above equation at a minimum requires entities to ensure that controls exist around the following processes: annual container inventory reports; tracking of SF<sub>6</sub> purchased, sold, or returned to vendors or other entities (including destruction and off-site recycling vendors); tracking SF<sub>6</sub> shipped in equipment or SF<sub>6</sub> included in “turnkey”-type projects from vendors or manufacturers; and tracking SF<sub>6</sub> asset’s nameplate capacity as SF<sub>6</sub> assets are removed and added into active equipment inventory.

The main difference between the two programs is demonstrated in CARB’s addition of recordkeeping measures around SF<sub>6</sub> equipment inventory<sup>5</sup> and container inventory. Besides Manufacturer, Equipment Voltage, Manufacturer Serial Number, Manufactured Date, and other information [L] usually found in an asset management system, CARB requires entities to maintain a chronological record of the dates on which SF<sub>6</sub> was transferred into or out of active GIS equipment including the amount of SF<sub>6</sub> transferred<sup>6</sup> [M]. In regards to container inventory management, the weight of each container as it is added or removed from inventory must also be tracked, in addition to a unique identification number, the size, and location of all containers [N]. The EPA regulation requires only the reporting of nameplate capacity of SF<sub>6</sub> equipment and the total pounds of SF<sub>6</sub> in containers at the beginning of the year and at the end of the year in relation to SF<sub>6</sub> equipment inventory and container inventory. Therefore, the CARB regulation requires additional effort by analysts, field crews, and management to ensure that all the required inputs for the Annual Report are being obtained, tracked, and reported accordingly.

**Note: Item [A] – [N] are highlighted above as these items will be mentioned in other sections of this paper. For quick reference, these items are identified below with their applicability to the relevant regulatory agency:**

Item	Item Description	Regulatory Agency
[A]	SF <sub>6</sub> stored in containers, but not in equipment, at the beginning of the year.	EPA/CARB
[B]	SF <sub>6</sub> stored in containers, but not in equipment, at the end of the year.	EPA/CARB
[C]	SF <sub>6</sub> purchased in bulk from chemical producers, distributors, or other entities.	EPA/CARB

<sup>4</sup> The use of the phrase “net increase in total nameplate capacity of active GIS equipment owned” in Equation DD-1 in 40 C.F.R. § 98.303 makes explicit that hermetically sealed assets are included in this determination. Hermetically sealed assets are not included within this item in the CARB regulation.

<sup>5</sup> Hermetically sealed SF<sub>6</sub> equipment and “inactive equipment” (i.e. SF<sub>6</sub> equipment retired for the given year and SF<sub>6</sub> equipment in storage) is included in CARB recordkeeping (but not emissions or emission rate calculations).

<sup>6</sup> Hermetically sealed SF<sub>6</sub> equipment and “inactive equipment” (i.e. SF<sub>6</sub> equipment retired for the given year and SF<sub>6</sub> equipment in storage) is not included in regards to tracking SF<sub>6</sub> transferred into or out of SF<sub>6</sub> equipment as it is not possible to transfer SF<sub>6</sub> into or out of hermetically sealed SF<sub>6</sub> equipment due to their design and “inactive equipment” do not have applicable gassing requirements.

Item	Item Description	Regulatory Agency
[D]	SF <sub>6</sub> purchased from equipment manufacturers, distributors, or other entities with or inside active GIS equipment.	EPA/CARB
[E]	SF <sub>6</sub> returned to site after off-site recycling.	EPA/CARB
[F]	SF <sub>6</sub> in bulk and contained in active GIS equipment that is sold to other entities.	EPA/CARB
[G]	SF <sub>6</sub> returned to suppliers.	EPA/CARB
[H]	SF <sub>6</sub> sent off-site for recycling.	EPA/CARB
[I]	SF <sub>6</sub> sent to destruction facilities.	EPA/CARB
[J]	The nameplate capacity of new active GIS equipment.	EPA/CARB
[K]	Nameplate capacity of retiring active GIS equipment.	EPA/CARB
[L]	SF <sub>6</sub> Equipment Manufacturer, Equipment Voltage, Manufacturer Serial Number, Manufactured Date, and other information.	CARB
[M]	Chronological record of the dates on which SF <sub>6</sub> was transferred into or out of active GIS equipment including the amount of SF <sub>6</sub> transferred.	CARB
[N]	Weight of each container as it is added or removed from inventory. A unique identification number, size, and location of all containers must also be tracked.	CARB

### SCE's Paper Process

In our voluntary involvement with the EPA SF<sub>6</sub> Partnership, SCE required substation field crews to create and track the following reports:

Report	Document Submittal Frequency
Residual Gas Report	Quarterly
Recycled Gas Report	Monthly
Reclaimed Gas Report	Due when cylinders are shipped to Material Coordinators
Inventory Report	Every January

The Residual Gas Report documents cylinders that have almost been fully expended of their gas value. These cylinders are to be sent back to the vendor with some residual SF<sub>6</sub> remaining in the cylinder. Some SF<sub>6</sub> gas must remain in the cylinder because a positive pressure is required for cylinders being returned to vendors. Field crews must populate this report as residual gas cylinders are leaving their inventory and being shipped back to the vendor. This report tracks multiple cylinders' bar codes, gross weights, tare weights, and net weights. Since multiple cylinders can be sent back to the vendor in the same shipment, multiple cylinders can be added to this single-page report form. This information is useful in obtaining the amount of SF<sub>6</sub> returned to suppliers (item **[G]**) in the reporting requirements.

The Recycled Gas Report documents the SF<sub>6</sub> gas removed from SF<sub>6</sub> equipment and added to SF<sub>6</sub> cylinders. This is gas that has been tested and shown to be of purity below the minimum SCE guidelines and therefore is described as “recycled” (also known as “bad” gas or “contaminated” gas). Typically, the reduced purity of this gas is due to handling errors or improper cylinder preparation. Field crews must populate the Recycled Gas Report as recycled gas cylinders are being filled with SF<sub>6</sub> gas from SF<sub>6</sub> equipment. The Recycled Gas Report is created at the equipment level and contains information for multiple cylinders’ bar codes, percent purity, gross weights, tare weights, and net weights. Since multiple cylinders can be used to extract SF<sub>6</sub> gas from equipment in an internal inspection or equipment removal/replacement, multiple cylinders can be added to this single-page report form. When the recycled gas cylinder is full, the cylinder is shipped off-site for recycling. This information is useful in obtaining the amount of SF<sub>6</sub> sent off-site for recycling (item **[H]**) in the reporting requirements.

The Reclaimed Gas Report documents SF<sub>6</sub> gas removed from SF<sub>6</sub> equipment and added to SF<sub>6</sub> cylinders. This is gas that has been tested and shown to be of purity greater than or equal to minimum SCE guidelines, and therefore is described as “reclaimed.” Reclaimed gas can be obtained in instances when retiring equipment from service where the replacement equipment requires less SF<sub>6</sub> gas than the new equipment. This surplus of gas must be adequately tracked and monitored. The Reclaimed Gas Report tracks multiple cylinders, since any of these cylinders can be reused in gassing SF<sub>6</sub> equipment. Field crews must populate this report as reclaimed gas cylinders are being filled with SF<sub>6</sub> gas from SF<sub>6</sub> equipment. This report contains a cylinder’s bar code, moisture content measured in parts per million, percent purity, gross weight, tare weight, and net weight. This information can affect the following items in the reporting requirements: SF<sub>6</sub> stored in containers, but not in equipment, at the end of the year (item **[B]**); SF<sub>6</sub> in bulk and contained in active GIS equipment that is sold to other entities (Item **[F]**); and SF<sub>6</sub> sent to destruction facilities (Item **[I]**).

The Inventory Report is essential in the SF<sub>6</sub> gas management process. Not considering SF<sub>6</sub> gas provided by manufacturers or other entities with or inside equipment, an entity’s gas usage should be based on the change in SF<sub>6</sub> gas inventory based on the SF<sub>6</sub> gas containers. Field crews must weigh all containers in the SF<sub>6</sub> container inventory. Since containers may be kept at different locations, all locations within a crew’s area of responsibility<sup>7</sup> must be weighed and taken under consideration. The report tracks multiple cylinders’ bar codes, gross weights, tare weights, and net weights. This information affects the following items in the reporting requirements: SF<sub>6</sub> stored in containers, but not in equipment, at the beginning of the year (Item **[A]**); SF<sub>6</sub> stored in containers, but not in equipment, at the end of the year (item **[B]**); SF<sub>6</sub> purchased in bulk from chemical producers, distributors, or other entities (Item **[C]**); and SF<sub>6</sub> returned to site after off-site recycling (Item **[E]**).

Other important reports that are required from our SF<sub>6</sub> gas cylinder vendor and other entities (including equipment manufacturers) for the given year are the following:

- Purchased Gas Container Report (Item **[C]**)

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<sup>7</sup> SCE defines the term “area of responsibility” as substations or equipment locations assigned to a field crew with the primary maintenance and inspection responsibility.

- Purchased Gas Report for cylinders that have undergone SF<sub>6</sub> gas recycling (Item **[E]**)
- Reports displaying SF<sub>6</sub> gas provided in equipment from the manufacturer or SF<sub>6</sub> gas provided through “turnkey”-type contract projects (Item **[D]**).

Vendors (including chemical producers, distributors, or other entities) may also be able to produce reports for residual gas (Item **[G]**) and recycled gas (Item **[H]**).

Our SAP asset management system is able to provide Master Data<sup>8</sup> around the nameplate capacity for all SF<sub>6</sub> equipment that presently exists, was retired during the year, or was added into inventory during the year. While initial information is added into SAP to facilitate the SF<sub>6</sub> equipment creation process (i.e. Manufacturer, Model Number, Serial Number, and Voltage), field crews obtain other related information as the SF<sub>6</sub> equipment is installed and put into service. The data input into SAP is handled by analysts. Nameplate capacity information is relevant to the calculation of nameplate capacity of new equipment (item **[J]**) and retired equipment (Item **[K]**) in the reporting requirements.

The document submittal frequency is important in ensuring accurate and timely information delivery. For example, even if no recycled gas is handled for a given time period, field crews are still required to submit a Recycled Gas Report (which reports zero activity). This effort aids in maintaining consistency for field crews and enables analysts to better keep track of field activity.

The above paper process should be sufficient for meeting requirements under the EPA Partnership and the reporting requirements under 40 C.F.R. Part 98 Subpart DD requirements. However, the challenges presented with the paper process are concentrated on the manual effort required to compile data into the proper format for data analysis and reporting. This effort is spent populating paper entries and digital submissions of paper entries into Microsoft (MS) Excel or MS Access for further manipulating.

## SCE's Electronic Process

### Revised Paper Process

The paper process solution worked well for aiding in producing annual emissions and the annual emission rate. Field crews only had to submit Residual Gas Reports, Recycled Gas Reports, Reclaimed Gas Reports, and Annual Inventory Reports, while analysts and specialists compiled the data for reporting purposes. This process was adequate for compliance with EPA's mandatory reporting in 2011. However, CARB's requirements to track SF<sub>6</sub> gas as it is transferred in and out of equipment and containers proved much more difficult to implement with paper documentation.

A revised paper process was initially implemented to meet the CARB requirements. Essentially, additional reports were added to our original paper process to facilitate the data-gathering effort

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<sup>8</sup> Master Data includes equipment Manufacturer, Model Number, Serial Number, Equipment Description, etc. including various other characteristic information in relation to the asset.

around CARB's SF<sub>6</sub> equipment inventory and container inventory tracking. All reports required under the revised paper process are shown below:

Report	Purpose	Affected Item(s) in Reporting Requirements <sup>9</sup>
Cylinder Storage Log	Track SF <sub>6</sub> gas containers entering and leaving storage area.	[A],[B],[C],[E],[F],[G],[H],[I],[M] <sup>10</sup> ,[N]
SF <sub>6</sub> Gassing Report <sup>11</sup>	Track SF <sub>6</sub> gas added to SF <sub>6</sub> equipment. Contains Master Data since related to SF <sub>6</sub> equipment.	[B],[M],[N]
Reclaimed SF <sub>6</sub> Gassing Report <sup>12</sup>	Track SF <sub>6</sub> gas removed from SF <sub>6</sub> equipment where purity meets or exceeds minimum SCE guidelines. Formerly known as the "Reclaimed Gas Report," but now contains more Master Data information since it relates to SF <sub>6</sub> equipment.	[B],[M],[N]
Recycled SF <sub>6</sub> Gassing Report <sup>13</sup>	Track SF <sub>6</sub> gas removed from SF <sub>6</sub> equipment where purity does not meet minimum SCE guidelines. Formerly known as the "Recycled Gas Report," but now contains more Master Data information since it relates to SF <sub>6</sub> equipment.	[B],[M],[N]
Residual Gas Report (for SF <sub>6</sub> Containers Sent Externally)	Track cylinders being returned to vendors or other entities with residual SF <sub>6</sub> gas.	[B],[F],[G],[I],[N]
Recycled Gas Report (for SF <sub>6</sub> Containers Sent Externally)	Track cylinders being returned to vendors or other entities with recycled SF <sub>6</sub> gas.	[B],[F],[H],[I],[N]
Quarterly Inventory Report	Track SF <sub>6</sub> gas container inventory. Note that the document submittal frequency changed to quarterly.	[A],[B]

While the revised paper process was sufficient to meet both EPA and CARB reporting requirements, challenges arose due to issues with duplicative information. Too many issues became apparent as various data elements had to be transferred between the different reports. For instance, sending a recycled gas container off-site for recycling involved an "OUT" entry on the Cylinder Storage Log and a separate Recycled Gas Report. Or, if a crew was conducting an internal inspection for a circuit breaker, the Reclaimed or Recycled Gassing Report (recall that report selection would be based on purity) would need to be created for the gas being removed from the circuit breaker, then a SF<sub>6</sub> Gassing Report would

<sup>9</sup> Refer to **A Quick Overview of EPA SF<sub>6</sub> Regulations and CARB SF<sub>6</sub> Regulations** section on pages 4-6 for full definition of items [A]-[N].

<sup>10</sup> Item [M] is included since if containers are tracked when transferring SF<sub>6</sub> gas in and out of equipment, then it can be determined when containers went in and out of storage area.

<sup>11</sup> Report is equipment type specific, i.e. for circuit breaker, switcher, etc.

<sup>12</sup> Report is equipment type specific, i.e. for circuit breaker, switcher, etc.

<sup>13</sup> Report is equipment type specific, i.e. for circuit breaker, switcher, etc.

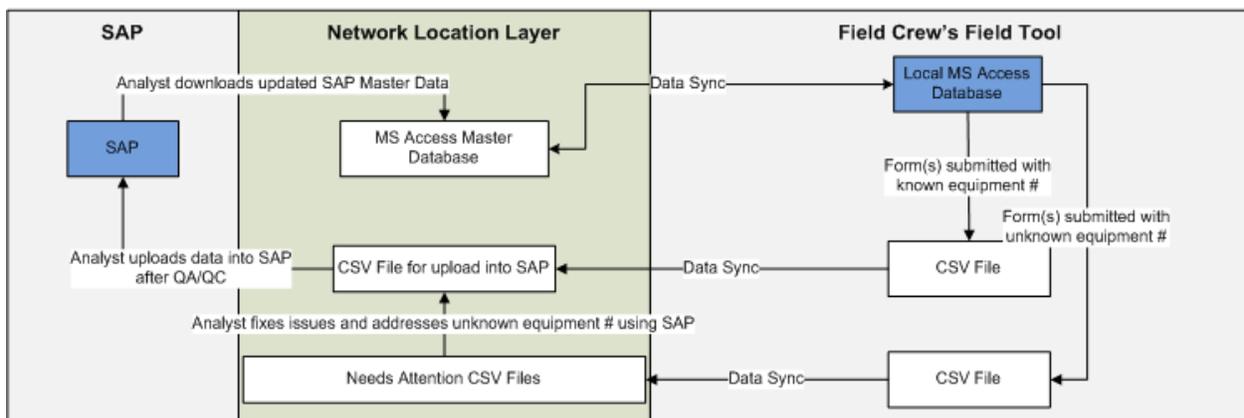
be required for the gas being added back to the circuit breaker. Since the gassing reports contained Master Data, this Master Data would need to be copied onto both forms.

Field crew resources were already expended in their routine efforts to inspect and maintain equipment, perform new equipment installations, and perform infrastructure replacement. Adding additional paperwork to their processes only made field crews’ lives more difficult. Furthermore, with all the SF<sub>6</sub>-related data being produced by field crews, there were also issues managing and processing this information by analysts. It became apparent that additional analysts may be needed to manually compile this data into a format conducive for analysis. Therefore, after realizing the efficiencies observed by utilizing the many features of our asset management system, it was determined that we needed to transition our paper process to an electronic solution.

**SAP Hybrid Interface Design**

SAP Interfaces transfer data from an external source into tables and data fields within SAP. These interfaces are usually real-time or scheduled interfaces that synchronize data between the external source and SAP. While an SAP Interface between a data-gathering tool and SAP would be the best solution (and is to be completed in the near future), SCE chose to create an in-house field tool (based on MS Access) that would utilize equipment and cylinder inventory Master Data to facilitate the capturing of the required SF<sub>6</sub> data utilizing a hybrid interface design.

The in-house field tool automatically synchronizes submitted data forms from the tool to a network location layer when an internet connection is detected. However, there is no real-time or scheduled SAP interface. Instead, there exists a network location layer that separates SAP and the in-house field tool located on the field crew’s field tool. The interface between the network location layer’s data “ready to be submitted into SAP” and SAP is a manual interface. This interface requires data to be handled by analysts, or “Gatekeepers”, prior to the data being uploaded into SAP. Any data issues or concerns will be addressed at the Gatekeeper stage prior to data being uploaded to SAP. After the data is uploaded into SAP, analysts will also download data from SAP into the network location’s MS Access Master Database. There is automatic data synchronization between this MS Access Master Database and the in-house field tool to ensure that updated Master Data from SAP exists in the tool. The above described hybrid interface is shown below in Figure 2.



**Figure 2: Electronic Process Hybrid Interface between SAP, Network Location Layer, and field crew's Field Tool.**

There is further effort in managing the in-house field tool and the interface between SAP and the network location layer. Additional programs (Java executable files) were created to facilitate the data syncing and data uploading at the Gatekeeper stage. The SAP data download for updated SAP Master Data in the in-house field tool is completed through standard SAP transactions (such as SAP Transaction IH08 – Display Equipment: Equipment Selection). Also, there exists some maintenance of the data in the M Access Master database. While this hybrid interface process may seem arduous, we believe that all the features aid in ensuring consistency and facilitate an overall effective process.

**SAP/BI Data Management**

SCE already utilized SAP and its related reporting system, Business Intelligence (BI), for numerous internal and external reports. SAP contained all the relevant Master Data for our SF<sub>6</sub> equipment inventory and purchase documentation information (such as invoices and receipts) for equipment and SF<sub>6</sub> gas containers. It made sense to migrate our SF<sub>6</sub> data to SAP in order to meet both CARB and EPA requirements while facilitating data gathering by field crews.

In the paper process, analysts had to manually manipulate and organize data obtained from field crews into MS Access or Excel for analysis and reporting. In SAP, we have decided to use SAP Measurement Documents created against SAP Measuring Points on Master Data elements (SAP equipment and/or functional location<sup>14</sup> record(s)) to manage data coming from field crews' reports. The SAP Measuring Point specifies the type of information that can be acquired, while the SAP Measurement Document gives a snapshot in time of a given piece of information.

For example, a SF<sub>6</sub> Gassing Report can track an equipment's moisture in parts per million **(1)**, percent purity **(2)** and total SF<sub>6</sub> gas added **(3)**, while the report also tracks the cylinder's weight before adding gas **(4)** and net weight after adding gas **(5)**. Five SAP Measurement Documents would be created for the 5 data points previously mentioned. However, since items **(3)**, **(4)**, and **(5)** represent SF<sub>6</sub> gas weight in pounds, only three SAP Measuring Points on the related Master Data elements (SAP equipment and/or functional location record(s)) are needed to facilitate the data creation (one for moisture in parts per million, one for purity in percent, and one for weight in pounds).<sup>15</sup>

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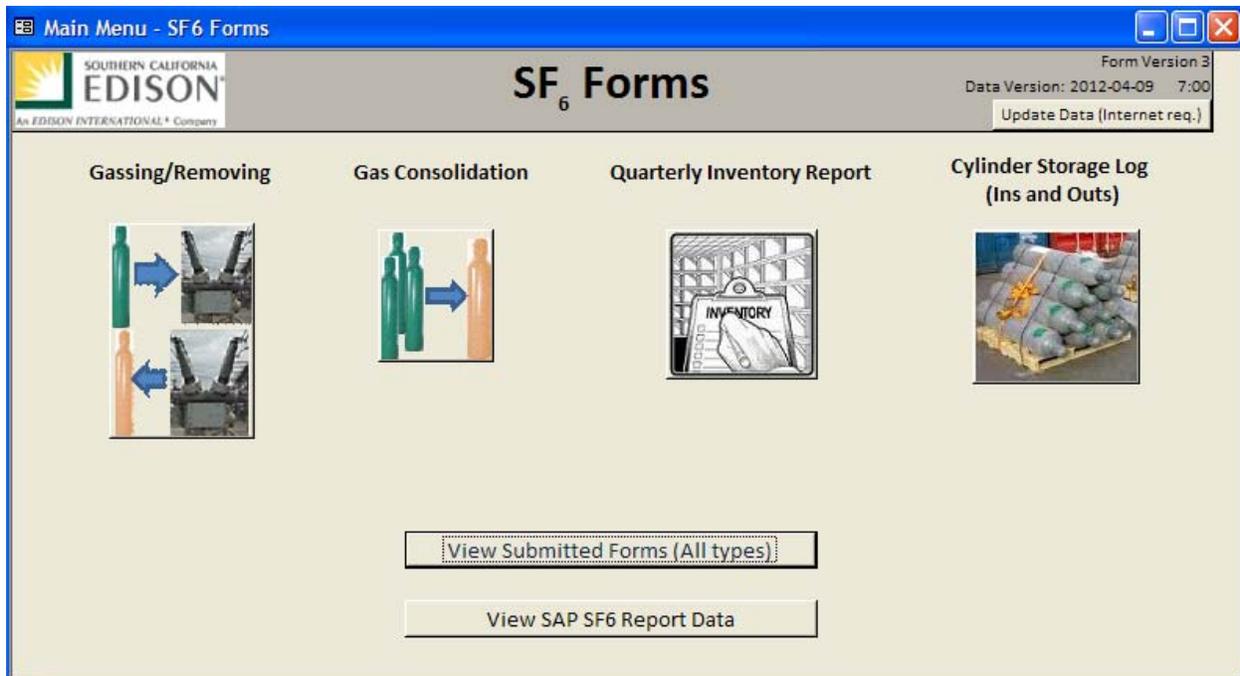
<sup>14</sup> The term "functional location" refers to the physical location of equipment. For instance, when a circuit breaker is replaced, the equipment is removed from the functional location, and new equipment is added to the functional location. In SAP, while the equipment number underneath the functional location changes, the functional location does not change.

<sup>15</sup> To better understand this example, observe a car's tachometer. The tachometer measures engine speed in revolutions per minute. A SAP Measuring Point would be similar to the tachometer, while a SAP Measurement Document would be similar to engine speed at a point in time. If engine speed at the present time or engine speed at a future time were required, then a single tachometer could be utilized for those two data points. Therefore, using this analogy, a single SAP Measuring Point can be used for multiple different SAP Measurement Documents.

SAP Code Groups and Codes, which will hereafter be referred to as **SAP Coding**, related to the SAP Measuring Points aid in characterizing the associated measurement documents. SCE's SAP Coding identifies Measurement Documents to the related field crews' submitted values in their reports. For instance, the "CBAD: CB – SF<sub>6</sub> Added" SAP Coding is created for Measurement Documents associated to SF<sub>6</sub> Gassing Reports for SF<sub>6</sub> equipment where SF<sub>6</sub> gas is being added to the asset. Whereas the "BTRM: Bottles – SF<sub>6</sub> Removed" SAP Coding is created for Measurement Documents associated to the SF<sub>6</sub> Gassing Reports for SF<sub>6</sub> containers where SF<sub>6</sub> gas is being removed from the asset. SAP Coding is essential to proper data management and analysis. Careful consideration should be given to selecting meaningful SAP Coding so that quality assurance methods and regulatory reports can be created with ease.

### The SF<sub>6</sub> Smart Form Tool

SCE's in-house field tool is known as the SF<sub>6</sub> Smart Form Tool. By policy, any time field crews handle SF<sub>6</sub> gas, they must utilize the SF<sub>6</sub> Smart Form Tool. The Main Menu for SCE's SF<sub>6</sub> Smart Form Tool is shown below in Figure 3.



**Figure 3: Screen shot of the Main Menu from SCE's SF<sub>6</sub> Smart Form Tool**

The SF<sub>6</sub> Smart Form Tool facilitates the data gathering effort for the EPA and CARB regulations. The following reports/forms are completed and submitted through the SF<sub>6</sub> Smart Form Tool:

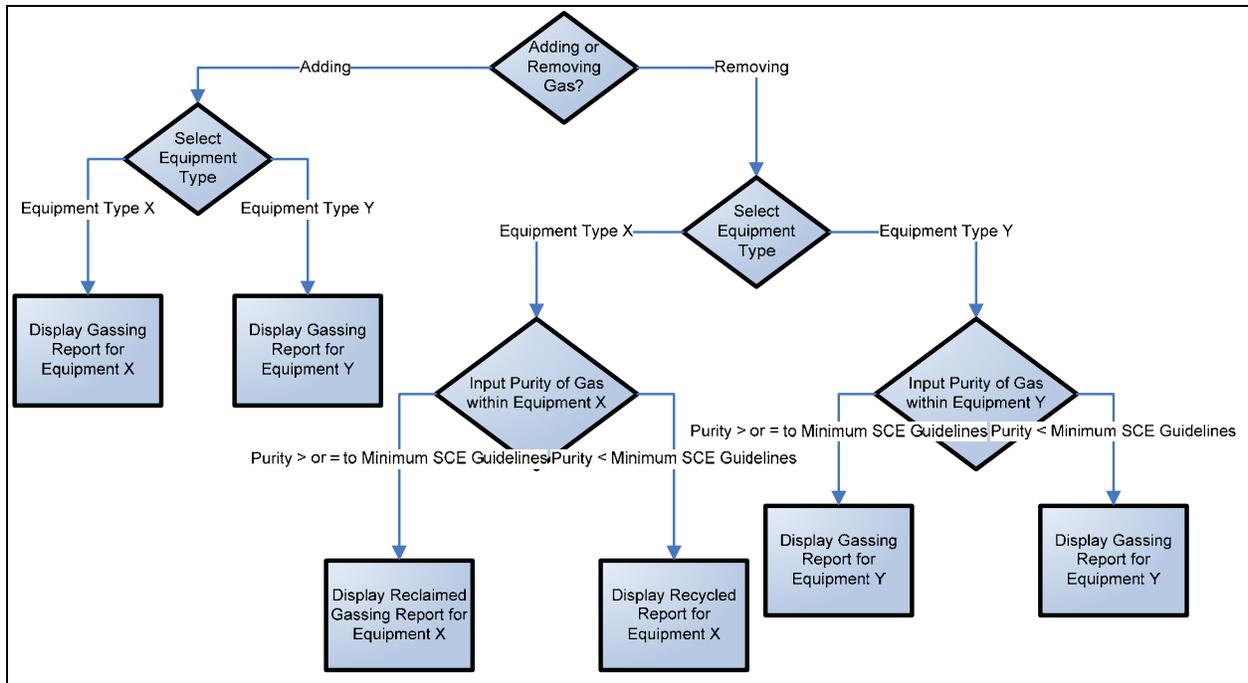
Report/Form	SF <sub>6</sub> Smart Form Tool Main Menu Option	Affected Item(s) in Reporting Requirements <sup>16</sup>
Cylinder IN	Cylinder Storage Log (Ins and Outs)	[A],[B],[C],[E],[M] <sup>17</sup> , [N]
Cylinder OUT Internal	Cylinder Storage Log (Ins and Outs)	[A],[B],[N]
Cylinder OUT External for Recycled Gas	Cylinder Storage Log (Ins and Outs)	[A],[B],[F],[H],[I],[N]
Cylinder OUT External for Residual Gas	Cylinder Storage Log (Ins and Outs)	[A],[B],[F],[G],[I],[N]
Quarterly Inventory Report	Inventory Report	[A],[B]
Reclaimed SF <sub>6</sub> Gas Report [Equipment Type Specific]	Gassing/Removing	[B],[M],[N]
Recycled SF <sub>6</sub> Gas Report [Equipment Type Specific]	Gassing/Removing	[B],[M],[N]
SF <sub>6</sub> Gas Consolidation Form	Gas Consolidation	[B],[N]
SF <sub>6</sub> Gassing Report [Equipment Type Specific]	Gassing/Removing	[B],[M],[N]

Unlike the paper process, since Master Data is found in the SF<sub>6</sub> Smart Form Tool, a duplicative effort across multiple forms is not necessary. SF<sub>6</sub> equipment Master Data is automatically populated when selecting the appropriate assets in the Gassing/Removing forms. SF<sub>6</sub> container Master Data information is available in drop-down menus to facilitate data entry by field crews when they are choosing which SF<sub>6</sub> containers in their inventory are being used to fill equipment.

Other procedures that required multiple steps due to the paper process have now been reduced. Recall the previously discussed issue with the Revised Paper Process concerning multiple reports for sending a recycled gas container off-site for recycling. The SF<sub>6</sub> Smart Form Tool creates both the Cylinder OUT Report and the Recycled Gas Report in a single entry. The Revised Paper Process required field crews to shift through multiple paper templates to select the correct paper template for their gassing scenario. The SF<sub>6</sub> Smart Form Tool has what is referred to as a Questionnaire. After field crew selects “Gassing/Removing” from the Main Menu, they are presented with options in regards to gassing SF<sub>6</sub> equipment. These options present one of six possible reports for use. Based on two different SF<sub>6</sub> equipment types, two forms are available for adding gas, two forms are available for removing reclaimed gas, and two forms are available for removing recycled gas. See Figure 4 for the Decision Tree logic for “Gassing/Removing” Reports.

<sup>16</sup> Refer to **A Quick Overview of EPA SF<sub>6</sub> Regulations and CARB SF<sub>6</sub> Regulations** section on page 4-6 for full definition of items [A]-[N].

<sup>17</sup> Item [M] is included because if containers are tracked when transferring SF<sub>6</sub> gas in and out of equipment, then it can be determined when containers went in and out of the relevant storage area.



**Figure 4: Decision Tree for SCE’s SF<sub>6</sub> Smart Form Tool’s Gassing/Removing Questionnaire**

As is visible through study of Figure 4’s Decision Tree, field crews’ efficiency in report selection is greatly increased.

The flexibility that comes with utilizing an electronic form also allowed us to expand some of the reports to gather additional information if required. For instance, on all six of the “Gassing/Removing” Reports, the *Reason for Gassing/Removing* is required to be populated before submitting the form. If New Installation is selected, then the tool will automatically display a field for obtaining the Initial SF<sub>6</sub> Gas Shipped in SF<sub>6</sub> Equipment from Manufacturer (Item **[D]**). It is ideal for field crews to have the ability to populate this data in the field tool because the Initial SF<sub>6</sub> Gas Shipped in SF<sub>6</sub> Equipment from Manufacturers can be provided (usually affixed to the SF<sub>6</sub> equipment) upon SF<sub>6</sub> equipment delivery. Much of the features discussed above are shown in Figure 5.

**SF<sub>6</sub> Gassing Report (CB)**  
(Pounds of SF<sub>6</sub> Transferred into CB)

The amount in pounds of SF<sub>6</sub> transferred into the Circuit Breaker (CB)  
A gassing report must be filled out each time SF<sub>6</sub> is added to a CB

SCE Username: LLOYDRP  
Date: 04/04/2012 MM/DD/YYYY Today  
Substation: ALPHA

**Equipment Information**

Equipment Name: CARDINAL 220KV CB  
Voltage: 230.00 kV  
Manufacturer: LLOYD  
Manufacturer Date: 5/10/2011 MM/DD/YYYY  
Model Number: 230KV/CB  
Serial Number: 4567890123  
Name Plate Insulating Quantity: 242

Reason for Adding SF<sub>6</sub>: New Installation  
Moisture After Adding Gas: 25 ppm  
Purity After Adding Gas: 99 %  
Initial Gas in CB from Manuf.: 120 lbs

**SF<sub>6</sub> Gas Cylinder Information**

Number of Cylinders Used: 1

Cylinder Owner	Bar Code Number	Weight Before Adding Gas	Weight After Adding Gas	Net Weight of Gas Added
Other	ABC123	210	130	80
Total SF <sub>6</sub> Gas Added				80

Annotations:  
 - Data pre-populated based on Asset Management System (points to SCE Username, Date, Substation)  
 - Drop-down allows only specific options to maintain consistency (points to Reason for Adding SF<sub>6</sub>)  
 - Tracks mass-balance equation element "gas purchased from equipment manufacturers inside equipment" (dynamic field appears only if "New Installation" is selected for Reason for Adding Gas) (points to Initial Gas in CB from Manuf.)  
 - Due to mandatory fields, all fields must be populated before report submittal (points to SF6 Gas Cylinder Information table)

Figure 5: SF<sub>6</sub> Gassing Report screen shot demonstrating features supported by SF<sub>6</sub> Smart Form Tool

### User Experience Scenario: The “Life” of a Gas Cylinder

The following process chart, detailed in Figure 6, will aid in understanding the typical scenario that field crews experience based on a SF<sub>6</sub> gas cylinder coming into their inventory, being used, and later being sent back to the vendor as residual gas. As stated, field crews must utilize the SF<sub>6</sub> Smart Form Tool when they handle SF<sub>6</sub> gas. Therefore, this scenario will be focused on the SF<sub>6</sub> Smart Form Tool’s use to produce the necessary data that is used in meeting reporting requirements.

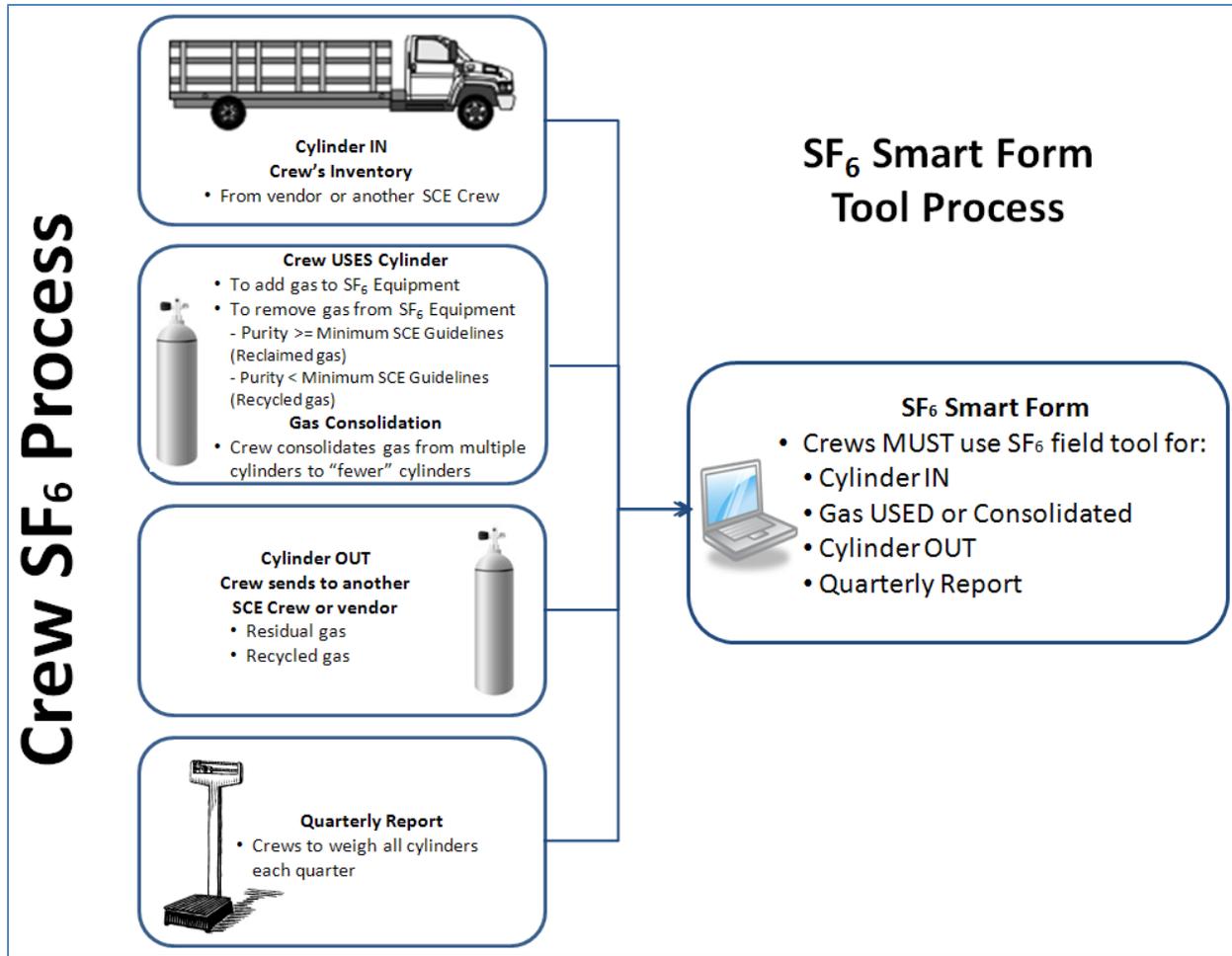


Figure 6: SF<sub>6</sub> Smart Form Tool Process from field crew perspective

- 1) A SF<sub>6</sub> gas cylinder is shipped from Vendor ABC and delivered directly to the XYZ Crew. As the SF<sub>6</sub> gas cylinder enters any Substation within XYZ Crew's AOR, the field crew must create the Cylinder IN entry using the SF<sub>6</sub> Smart Form Tool. The Cylinder IN Report would be represented with the below data:

Report	Crew	Date	Cylinder Owner	Serial Number	% Purity	Moisture (ppm)	Tare Weight (lbs)	Net <sup>18</sup> Weight (lbs)
Cylinder IN	XYZ	01/20/20XX	ABC	ABC123	99	25	115	100

- 2) A low gas alarm is received on a SF<sub>6</sub> circuit breaker (SAP Equipment Number 1234567890) at Substation Alpha. XYZ Crew must add gas to the SF<sub>6</sub> circuit breaker to bring it back to nameplate

<sup>18</sup> Net Weight = Gross Weight – Tare Weight. Gross Weight is not shown here as this information does not need to be tracked as it can be deduced from the Tare Weight (which is required regulation information) and Net Weight (which is the amount of SF<sub>6</sub> gas in the SF<sub>6</sub> container).

capacity. Two gassing reports would be created in this example: one gassing report for the circuit breaker, and another gassing report for the cylinder. However, the SF<sub>6</sub> Smart Form Tool facilitates the creation of both reports for the field crew's single entry (the single entry's data is comprehensive of the information below):

Report	Crew	Date	SAP Equipment Number	Reason for Adding Gas	% Purity After Adding Gas	Moisture After Adding Gas (ppm)	Net Weight of Gas Added (lbs)
SF <sub>6</sub> Gassing Report (CB - SF <sub>6</sub> Added)	XYZ	02/03/20XX	1234567890	Low Gas	99	25	5

**SF<sub>6</sub> Gassing Report for SF<sub>6</sub> Circuit Breaker**

Report	Crew	Date	SAP Equipment Number	Cylinder Owner	Serial Number	Weight Before Adding Gas (lbs)	Net Weight of Gas Added (lbs) <sup>19</sup>
SF <sub>6</sub> Gassing Report (Cylinder - SF <sub>6</sub> Removed)	XYZ	02/03/20XX	1234567890	ABC	ABC123	215	-5 <sup>20</sup>

**SF<sub>6</sub> Gassing Report for SF<sub>6</sub> Cylinder**

- 3) It is the end of the quarter, and the 1<sup>st</sup> Quarter Inventory Report is due. XYZ Crew must weigh all gas cylinders used for the quarter, and the ABC123 cylinder would be one cylinder on a list of many within the crew's area of responsibility that is to be identified in the report. Since this 1<sup>st</sup> Quarter Inventory Report is primarily for quality assurance use, there is minimal information that is obtained by the SF<sub>6</sub> Smart Form Tool. The entry for the ABC123 cylinder would appear as follows:

Report	Crew	Date	Cylinder Owner	Serial Number	Net Weight (lbs)
Quarterly Inventory Report (1 <sup>st</sup> Quarter)	XYZ	4/10/20XX	ABC	ABC123	95

<sup>19</sup> Net Weight of Gas Added = Weight Before Adding Gas – Weight After Adding Gas. Weight After Adding Gas is not shown here as this information can be deduced from the Weight Before Adding Gas (which is captured for quality assurance purposes) and Net Weight of Gas Added.

<sup>20</sup> Negative numbers are used because SF<sub>6</sub> gas was removed from the cylinder.

- 4) The XYZ Crew is installing a new SF<sub>6</sub> circuit breaker in a new position within Substation Beta’s 230 kV switchrack. This SF<sub>6</sub> circuit breaker has a nameplate capacity of 242 pounds of SF<sub>6</sub> gas and contained 120 pounds of SF<sub>6</sub> gas upon arrival at the substation. The 120 pounds of SF<sub>6</sub> gas was shipped in the circuit breaker and originated from the manufacturer. Even though multiple cylinders will be used to fill this new circuit breaker to nameplate capacity, only the ABC123 cylinder will be shown below. Recall that similar to Item (2) in the User Experience Scenario, multiple gassing reports will be created: one gassing report for the circuit breaker and then other gassing reports for the cylinders used to add gas to the circuit breaker.

Report	Crew	Date	SAP Equipment Number	Reason for Adding Gas	Initial Gas in Equipment from Manufacturer (lbs)	% Purity After Adding Gas	Moisture After Adding Gas (ppm)	Net Weight of Gas Added (lbs)
SF <sub>6</sub> Gassing Report (CB - SF <sub>6</sub> Added)	XYZ	05/10/20XX	1987654320	New Installation	120	99	25	122 <sup>21</sup>

**SF<sub>6</sub> Gassing Report for SF<sub>6</sub> Circuit Breaker**

Report	Crew	Date	SAP Equipment Number	Cylinder Owner	Serial Number	Weight Before Adding Gas (lbs)	Net Weight of Gas Added (lbs) <sup>22</sup>
SF <sub>6</sub> Gassing Report (Cylinder - SF <sub>6</sub> Removed)	XYZ	05/10/20XX	1987654320	ABC	ABC123	210	-80 <sup>23</sup>

**SF<sub>6</sub> Gassing Report for SF<sub>6</sub> Cylinder**

Note that an additional SF<sub>6</sub> Gassing Report (Cylinder – SF<sub>6</sub> Removed) would exist for the other SF<sub>6</sub> cylinder that contributed 42 pounds of SF<sub>6</sub> gas to fill the circuit breaker to nameplate capacity. [42 pounds of SF<sub>6</sub> from this additional cylinder + 80 pounds of SF<sub>6</sub> from Cylinder ABC123 + 120 pounds of SF<sub>6</sub> initially in circuit breaker from Manufacturer = 242 pounds of SF<sub>6</sub> which was identified as the nameplate capacity of the circuit breaker].

<sup>21</sup> With circuit breaker nameplate capacity of 242 pounds and 120 pounds of SF<sub>6</sub> initially in the circuit breaker, 122 pounds of SF<sub>6</sub> gas would be needed to fill the circuit breaker to nameplate capacity.

<sup>22</sup> Net Weight of Gas Added = Weight Before Adding Gas – Weight After Adding Gas. Weight After Adding Gas is not shown here as this information does not need to be tracked as it can be deduced from the Weight Before Adding Gas (which is captured for quality assurance purposes) and Net Weight of Gas Added.

<sup>23</sup> Negative numbers are used as SF<sub>6</sub> gas was removed from the cylinder. Also, cylinder ABC123 had 95 pounds of SF<sub>6</sub> gas as of 04/10/20XX according to the 1<sup>st</sup> Quarter Inventory Report. The reason why 80 pounds of SF<sub>6</sub> gas instead of 95 pounds of SF<sub>6</sub> gas was used to fill the new circuit breaker to nameplate capacity is because some SF<sub>6</sub> gas must remain in the cylinder as a positive pressure is required for cylinders being returned to vendors (as stated in the Residual Gas explanation in the **SCE’s Paper Process** section on page 6).

- 5) Since most of the SF<sub>6</sub> gas in Cylinder ABC123 has been expended, XYZ Crew will prepare the cylinder for a residual gas shipment to the vendor ABC. A Cylinder OUT External for Residual Gas Report would be created. The SF<sub>6</sub> Smart Form Tool creates two reports for the single entry: one report for the Cylinder OUT and another report for the Residual Gas Report. Cylinder OUT Reports are created when a Field Crew ships a SF<sub>6</sub> gas container outside the crew’s AOR internally or externally, while Residual Gas Reports (and also Recycled Gas Reports) are only created if a Cylinder OUT is being shipped externally outside a crew’s AOR. The Cylinder OUT Report and Residual Gas Report is shown below.

Report	Crew	Date	Shipped To	Cylinder Owner	Serial Number	Net Weight (in lbs)
Cylinder OUT	XYZ	06/15/20XX	Vendor ABC	ABC	ABC123	15
Residual Gas Report	XYZ	06/15/20XX	Vendor ABC	ABC	ABC123	15

**User Scenario Analysis/Reporting**

In summary, the following gassing transactions transpired for Cylinder ABC123 from 01/20/20XX through 06/15/20XX:

SF <sub>6</sub> Cylinder Gas Usage: ABC - ABC123 [Cylinder Owner - Serial Number]			
Date	Report	Gas Usage (lbs)	Affected Item(s) in 20XX Year Reporting <sup>24</sup>
01/20/20XX	Cylinder IN	100	[C],[N]
02/03/20XX	Gassing Report	-5	[M],[N]
04/10/20XX	Quarterly Inventory Report	95	N/A
05/10/20XX	Gassing Report	-80	[D],[M],[N]
06/15/20XX	Cylinder OUT	15	[N]
06/15/20XX	Residual Gas Report	15	[G]

All required data is captured for accurate reporting of the details behind Cylinder ABC123. The Cylinder IN Report captures SF<sub>6</sub> gas purchased for vendors (Item **[C]**) and also tracks the date the cylinder enters inventory (Item **[N]**). The Gassing Report on 02/03/20XX captures the date and amount of SF<sub>6</sub> gas transferred into equipment (Item **[M]**). This Gassing Report also can be used to determine parameters around the cylinder entering and leaving inventory (Item **[N]**). The Quarterly Inventory Report exists purely for quality assurance use which will be explained in the next section. The Gassing Report on 05/10/20XX captures not only the date and amount of SF<sub>6</sub> gas transferred into equipment (Item **[M]**),

<sup>24</sup> Refer to **A Quick Overview of EPA SF<sub>6</sub> Regulations and CARB SF<sub>6</sub> Regulations** section on pages 4-6 for full definitions of items [A]-[N].

but it also captures SF<sub>6</sub> gas purchased from manufacturers inside equipment (Item **[D]**). This Gassing Report also can be used to determine parameters around the cylinder entering and leaving inventory (Item **[N]**). The Cylinder OUT Report tracks the date and amount of SF<sub>6</sub> gas leaving inventory (Item **[N]**). Finally, the Residual Gas Report tracks the amount of residual gas that is returned to vendors (Item **[G]**).

As the field crews submit the above reports from User Experience Scenario Items (1) through (5) on the SF<sub>6</sub> Smart Form Tool, the data points get uploaded to the Gatekeeper for review. The Gatekeeper reviews the data for accuracy and uploads the data into SAP. This information is now available for ad-hoc reports through standard SAP Transaction IK17 - Display Measurement Documents: Measurement Document Selection. From SAP, the SF<sub>6</sub> data syncs with SAP BI, where we are then able to generate reports for management to ensure that we are handling gas accordingly. These reports go through much scrutiny and analysis by analysts based on our SF<sub>6</sub> Quality Assurance Methods. We are then able to produce the required reports from BI with little effort for reporting to both EPA and CARB.

### **SF<sub>6</sub> Quality Assurance Methods**

We have three different reports that analyst generate to determine the accuracy and effectiveness of the data that is being generated from field crews:

- 1) Missing Gas Report Analysis,
- 2) Missing IN/OUT/Inventory Report Analysis, and
- 3) General SF<sub>6</sub> Report

Also, as field crews submit data from their SF<sub>6</sub> Smart Form Tool to the Network Location Layer, the Gatekeepers check for duplicates in SAP prior to submission and look for any suspect data (nonsensical values, date checks, etc.).

### **Missing Gas Reporting Analysis**

Missing Gas Report Analysis involves tracking SF<sub>6</sub> gas in SF<sub>6</sub> gas containers. This analysis tracks the use of gas cylinders over a period of time and identifies where gas values do not match. We have instituted two different methods to identify missing gas. One method is to determine discrepancies between the current Gassing Report and the previous Gassing Report. The summation of the previous Gassing Report's "Weight Before Adding Gas" and "Net Weight of Gas Added" should equal the current Gassing Report's "Weight Before Adding Gas." This method can better be understood by referring back to the User Experience Scenario.

User Experience Scenario	Date	Report	Report Measure	Cylinder Owner - Serial Number	Report Measure Weight (lbs)
(1)	01/20/20XX	Cylinder IN	Net Weight	ABC - ABC123	100
(2)	02/03/20XX	Gassing Report	Weight Before Adding Gas	ABC - ABC123	215
(2)	02/03/20XX	Gassing Report	Net Weight of Gas Added	ABC - ABC123	-5

Expected "Weight Before Adding Gas" on next Gassing Report

$$215 + (-5) = 210$$

(3)	04/10/20XX	Quarterly Inventory Report	Net Weight	ABC - ABC123	95
(4)	05/10/20XX	Gassing Report	Weight Before Adding Gas	ABC - ABC123	210
(4)	05/10/20XX	Gassing Report	Net Weight of Gas Added	ABC - ABC123	-80

Expected "Weight Before Adding Gas" on next Gassing Report

$$210 + (-80) = 130$$

(5)	06/15/20XX	Cylinder OUT	Net Weight	ABC - ABC123	15
-----	------------	--------------	------------	--------------	----

By tracking "Weight Before Adding Gas," we are able to determine future Gassing Report "Weight Before Adding Gas" by the summation of the "Weight Before Adding Gas" and "Net Weight of Gas Added" [red arrows in example above]. If the "Weight Before Adding Gas" on 05/10/20XX [yellow arrow in example above] was anything other than 210 pounds of SF<sub>6</sub> gas, then the discrepancy would need to be investigated as there should have been a Gassing Report submitted between the date of the previously received Gassing Report and the currently received Gassing Report (for our example, the missing gas would be between 02/03/20XX and 05/10/20XX). Note that in the above example, even though the expected "Weight Before Adding Gas" on the Gassing Report after 05/10/20XX is 130 pounds of SF<sub>6</sub>, a missing gas analysis is not necessary to complete because the cylinder was shipped out of inventory on 06/15/20XX. This method to determine missing gas is effective; however, this would not show missing gas if no previous Gassing Report or current Gassing Report were created. This scenario would exist if a crew was not utilizing the SF<sub>6</sub> Smart Form Tool when gassing SF<sub>6</sub> equipment. The second method takes into consideration this shortcoming of missing Gassing Reports.

The second missing gas method analyzes SF<sub>6</sub> gas container data from the Cylinder IN Report through the Quarterly Inventory Report and/or through the Cylinder OUT Report. This analysis involves tracking actual and expected SF<sub>6</sub> gas as Cylinder IN Reports, Quarterly Inventory Reports, and Cylinder OUT Reports regarding the SF<sub>6</sub> cylinder are created. These three reports collectively will hereafter be referred

to as “Reference Reports.” Once again, we will utilize the User Experience Scenario for better understanding.

User Experience Scenario	Date	Report	Report Measure	Cylinder Owner - Serial Number	Report Measure Weight (lbs)
(1)	01/20/20XX	Cylinder IN	Net Weight	ABC - ABC123	100
(2)	02/03/20XX	Gassing Report	Weight Before Adding Gas	ABC - ABC123	215
(2)	02/03/20XX	Gassing Report	Net Weight of Gas Added	ABC - ABC123	-5
(3)	04/10/20XX	Quarterly Inventory Report	Net Weight	ABC - ABC123	95
Expected pounds of SF <sub>6</sub> gas added/removed from cylinder between 01/20/20XX (Cylinder IN) and 04/10/20XX (Quarterly Inventory Report)					
(4)	05/10/20XX	Gassing Report	Weight Before Adding Gas	ABC - ABC123	210
(4)	05/10/20XX	Gassing Report	Net Weight of Gas Added	ABC - ABC123	-80
(5)	06/15/20XX	Cylinder OUT	Net Weight	ABC - ABC123	15
Expected pounds of SF <sub>6</sub> gas added/removed from cylinder between 04/10/20XX (Quarterly Inventory Report) and 06/15/20XX (Cylinder OUT)					

Comparing the Reference Reports enables us to determine the amount SF<sub>6</sub> gas added or removed from a cylinder between a Cylinder IN and Quarterly Inventory Report, Quarterly Inventory Report and Cylinder OUT, or Cylinder IN and Cylinder OUT. If the expected pounds of SF<sub>6</sub> gas added or removed for the period between Reference Reports does not match the actual pounds of SF<sub>6</sub> gas, then there must be missing Gassing Reports between the two dates. While this method identifies missing gas when no other Gassing Reports exist, the downside is that this analysis can only be done on a quarterly basis or when a Cylinder OUT Report is created for a specific SF<sub>6</sub> gas container. Therefore, both the first and second missing gas methods are performed to ensure accurate data. Another shortcoming is found when there is no Cylinder IN Report, Quarterly Inventory Report, or Cylinder OUT report to perform data analysis against. The missing IN/OUT/Inventory Report analysis addresses this gap.

**Missing IN/OUT/Inventory Report Analysis**

The IN/OUT/Inventory Report Analysis identifies missing Reference Reports. While the missing IN/OUT/Inventory Report Analysis does not locate missing Gassing Reports, it does facilitate the second missing gas identification method mentioned above. This analysis requires at least one Reference Report

to exist. Through data analysis, if only a single entry exists for a cylinder and it is identified on the Quarterly Inventory Report, then it is apparent that the Cylinder IN Report was not created. If a cylinder no longer appears on a Quarterly Inventory Report when it existed on a previous quarter's inventory report, then it can be deduced that a Cylinder OUT Report was not created. If a Cylinder IN Report exists with a date prior to the recent Quarter Inventory Report, and the cylinder does not appear on the Quarterly Inventory Report, then there may be a missing Cylinder OUT Report OR a missing record for the cylinder on the Quarterly Inventory Report. This IN/OUT/Inventory Report Analysis is more difficult to analyze and usually requires close collaboration with field crews to resolve issues.

### **General SF<sub>6</sub> Report**

The final Quality Assurance Report is the General SF<sub>6</sub> Report. The General Report has a dashboard of all SF<sub>6</sub> Reports submitted by the field crews. Field supervisors, management, and others are able to view data submitted and interject changes when issues are identified. This method's effectiveness depends on the frequency of field crews' review of the data that has been submitted.

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While SCE's paper process met EPA requirements, this paper process was not sufficient for the CARB requirements. The revised paper process was able to meet CARB requirements, but with additional challenges to field crews and office personnel. By transitioning to an electronic process, SCE is able to meet EPA and CARB requirements while experiencing many benefits. Our field crews are better able to keep track of their information since the tool makes available past submitted forms. Field crews are able to be guided through the SF<sub>6</sub> Smart Form Tool's Reports due to mandatory fields so that data entry is consistent and errors in submission are avoided. Supervisors and management are able to get immediate information on the data being created by crews directly from SAP or through monthly SF<sub>6</sub> Reports from the SAP BI Reporting system. Field crew efficiency is increased since a single report entry creates multiple reports. With all of this data, we are able to more quickly identify leaking equipment and increase their priority for replacement which in turn directly affects our emission rate. These are just a few of the many benefits that were experienced due to the transitioning of our paper process to an electronic process.

Through our trials and challenges in developing our SF<sub>6</sub> process and through the recognition of the importance of SF<sub>6</sub> emission reduction requirements, we have acquired much knowledge implementing and maintaining an efficient, sustainable program. These concepts presented throughout this paper highlight the facets of our program that have contributed to the lowering of our emission rates. We hope that the knowledge that is presented will aid other entities in creating or even modifying their SF<sub>6</sub> programs.

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## Author Biography

Robert Preston Lloyd is a Senior Technical Specialist at Southern California Edison. Robert is responsible for Substation Compliance & Asset Management and has held numerous positions of various capacities and technical competencies. His involvement in compliance and regulatory issues within the electric utility industry includes experience with General Rate Cases, audits, reporting, strategy, process development, and standard drafting teams. Most recently, he was selected to become a member of the NERC Critical Infrastructure Protection Standard Drafting Team for Version 5 of the NERC Cyber-security Standards. Additionally, his many years of activity in asset management includes being a Project Manager in Southern California Edison's Enterprise Resource Planning SAP implementation.

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