

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Railroad, Pipeline and Hazardous Materials Investigations

Human Performance and Survival Factors Division

February 2, 2011

HUMAN PERFORMANCE GROUP FACTUAL FINDINGS

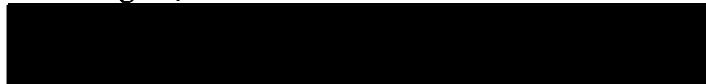
**A. ACCIDENT**

The rupture and explosion of natural gas line 132 owned and operated by Pacific Gas and Electric Company (PG&E) at about 6:11 p.m.<sup>1</sup> on September 9, 2010 in San Bruno, California.

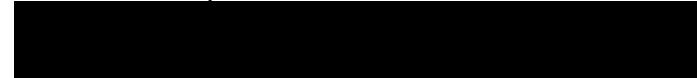
NTSB accident number: DCA-10-MP-008

**B. HUMAN PERFORMANCE GROUP**

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**C. SUMMARY OF THE ACCIDENT**

On September 9, 2010, at approximately 6:11 p.m. Pacific Daylight Time, a 30-inch diameter section of a multi-diameter intra-state natural gas transmission pipeline (Line 132) owned and operated by Pacific Gas & Electric Company (PG&E) ruptured in a residential area in San Bruno, California. The rupture occurred at approximately mile point (MP) 39.28, at the intersection of Earl Avenue and Glenview Drive in the city of San Bruno. PG&E estimated that 47.6 million standard cubic feet (MMSCF) of natural gas were released as a result of the rupture. The rupture

<sup>1</sup> Unless otherwise indicated, all times are denoted in Pacific Daylight Time.

created a crater approximately 72 feet long by 26 feet wide. A pipe segment approximately 28 feet long was found about 100 feet south of the crater. The released natural gas was ignited sometime after the rupture; the resulting fire destroyed 38 homes and damaged 63. Eight people were killed, numerous individuals were injured, and many more were evacuated from the area. On September 10, the NTSB launched a team to California to investigate this tragedy.

Line 132 is regulated by the California Public Utilities Commission (CPUC). According to the PG&E survey sheets, the ruptured pipe (part of Segment 180 that is approximately 1,742-foot long) was constructed from 30-inch diameter seamless steel pipe (API 5LX) Grade X42 with 0.375-inch thick wall. The pipeline was coated with hot applied asphalt, and was cathodically protected. The ruptured pipeline segment was installed circa 1956. The specified maximum operating pressure (MOP) for the ruptured pipeline was 375 pounds per square inch gauge (psig). According to PG&E, the maximum allowable operating pressure (MAOP) for the line was 400 psig. Just before the accident, PG&E was working on their uninterruptable power supply (UPS) system at Milpitas Terminal, which is located about 39.28 miles southeast of the accident site.

#### **D. DETAILS OF THE ACCIDENT**

##### **1. Behavioral Factors**

###### **a. *96-hour work/rest history.***

(1). A gas control technician (GCT) on duty at the Milpitas terminal at time of the accident. The GCT recalled that he awoke at 5:30 a.m. on Sunday, September 5. He then visited family and retired for the evening at 9:00 p.m. He arose the following morning Monday, September 6 between 5:30 a.m. and 6:00 a.m., remained home and retired for the evening at 8:00 p.m. He awoke the following morning, Tuesday September 7 at 3:15 a.m. drove to Hollister, California and reported for duty at 6:00 a.m. He went off duty at 4:30 p.m. and retired for the evening at 9:00 p.m. On Wednesday September 8 he awoke at 4:45 a.m., reported for work at 6:00 a.m. and worked until 5:00 p.m. He retired that evening at 9:00 p.m. He awoke the following morning Thursday, September 8 at 4:45 a.m. and reported for duty at 6:00 a.m.

At the time of the accident the operator had been awake for about 13 hours, 26 minutes and had been on duty for about 12 hours, 11 minutes.

(2). An apprentice gas technician (AGT) on duty at the Milpitas terminal at the time of the accident. The AGT recalled that he awoke about 10:00 a.m. Sunday, September 5 while in Reno, Nevada. He returned to his residence between 4:30 p.m. and 5:00 p.m. and he retired for the evening at 11:00 p.m. He arose the following morning, Monday, September 6 at 9:00 a.m. and remained home. He retired for the evening at 9:30 p.m. He arose the following morning, Tuesday, September 7 at 6:30 a.m., reported for work at 7:00 a.m., worked until 3:30 p.m. and retired for the evening at 10:00 p.m. He awoke at 5:20 a.m. the following morning Wednesday, September 8 arrived at work at 6:00 a.m., went off duty at 4:30 p.m. and retired for the evening at 9:30 p.m. He arose the following morning Thursday, September 9 at 5:20 a.m. and reported for work at 6:00 a.m.

At the time of the accident he had most recently been awake for about 12 hours, 51 minutes and had been on duty for about 12 hours, 11 minutes.

(3). A technical sub foreman (TSF) on duty at the Milpitas terminal at the time of the accident. The TSF recalled that he arose at 7:30 a.m. Sunday, September 5, remained at home, and then drove to Milpitas and retired for the evening at 10:00 p.m. He awoke the following morning, Monday, September 6 at 4:45 a.m., reported for duty at 6:00 a.m. and finished work at 4:30 p.m. He retired for the evening at 9:00 p.m. The TSF said that he followed this same routine the following 3 days: Tuesday, September 7, Wednesday September 8 and Thursday, September 9.

At the time of the accident, he had most recently been awake for about 13 hours, 26 minutes and had been on duty for about 12 hours, 11 minutes.

(4). A PG&E contractor on duty at the Milpitas terminal at the time of the accident. The contractor recalled that he awoke at about 8:30 a.m., Sunday, September 5 while he was visiting Lake Tahoe, CA and retired that evening at 11:00 p.m. He awoke the following day, Monday, September 6 at 8:00 a.m., returned from Lake Tahoe and retired for the evening at 11:30 p.m. He arose the following morning, Tuesday, September 7 between 8:00 a.m. and 9:00 a.m., ran errands, and retired for the evening at 11:30 p.m. He remained home the following day, Wednesday, September 8 after arising between 8:00 a.m. and 9:00 a.m. and retired for the evening at 11:30 p.m. He awoke the following morning, Thursday, September 9 at 7:00 a.m. and arrived at Milpitas terminal at about 1:30 p.m.

At the time of the accident he had been awake for about 11 hours, 11 minutes, and had been on duty for about 4 hours, 41 minutes.

(5). A gas transmission coordinator (GTC) on duty at the Supervisory Control and Data Acquisition (SCADA) center in San Francisco, California. The GTC recalled that he arose at 9:00 a.m. Sunday, September 5, and retired between 9:30 p.m. and 10:00 p.m. He awoke the following day, Monday, September 6 at between 8:00 a.m. and 9:00 a.m. and retired about 10:00 p.m. The following day, Tuesday, September 7 he arose at 4:30 a.m., worked from 6:00 a.m. until 6:00 p.m. and retired for the evening between 9:00 p.m. and 9:30 p.m. The GTC said he followed the same pattern of awakening, working and retiring the following 2 days: Wednesday, September 8 and Thursday, September 9.

At the time of the accident he had been awake for about on duty for about 13 hours, 41 minutes and had been on duty for about 12 hours, 11 minutes.

(6). A senior GTC (SGTC) on duty at the SCADA center in San Francisco, California. The SGTC recalled that he had worked Saturday, September 4 and he had retired between 7:00 a.m. and 7:30 a.m. on Sunday, September 5 upon returning home. He arose later that day at 3:30 p.m., returned to work at 5:45 p.m. and worked until 6:00 a.m. the following day, Monday, September 6. He arrived home later that morning, napped and remained home and retired for the evening at 8:30 p.m. He awoke the following day, Tuesday, September 7 at 7:00 a.m., remained home then retired between 8:30 a.m. an 9:30 p.m. He arose the following day, Wednesday, September 8 at 4:15 a.m. He had worked from 5:45 a.m. until 6:00 p.m., returned home and retired at 8:00 p.m. He arose the following morning, Thursday, September 9 at 4:15 a.m., reported for duty at 5:45 a.m. and went off duty at 10:00 p.m.

At the time of the accident he had been awake for just under 14 hours, and had been on duty

for about 12 hours, 26 minutes.

(7). A gas system operator (GSO) on duty at the SCADA center in San Francisco, California. The GSO recalled that he awoke between 9:00 a.m. and 10:00 a.m. on Sunday, September 5 and he had retired for the evening by 11:00 p.m. He arose the following day, Monday, September 6 at 9:00 a.m. and retired at 9:00 p.m. On Tuesday, September 7 he awoke at 3:00 a.m., arrived to work by 5:30 a.m., worked until 5:30 p.m., returned home and retired by 9:00 p.m. He said he followed the same pattern of awakening, working and retiring the following 2 days. Wednesday, September 8 and Thursday, September 9.

At the time of the accident he had been awake for about 15 hours, 11 minutes and had been on duty for about 12 hours, 41 minutes.

(8). A GSO on duty at the SCADA center in San Francisco, California.<sup>2</sup> The GSO reported that Monday and Tuesday were his days off. He typically retired each evening on those days between 10:30 p.m. and 11:30 p.m., and he typically arose the following mornings between 6:30 a.m. and 7:00 a.m. to prepare his children for school. On Wednesday, September 8 and Thursday, September 9, he retired both evenings at 9:30 p.m. and he had awoke the following morning at 4:00 a.m. He reported for duty both days at 6:00 a.m. His normal work hours were 6:00 a.m. to 6:00 p.m.

At the time of the accident he had been awake for about 14 hours, 11 minutes and had been on duty for about 12 hours, 11 minutes.

(9). A Measurement and Control GSO (GSOMC) on duty at the SCADA center in San Francisco, California.<sup>3</sup> The GSOMC reported that he awoke at 8:00 a.m. Sunday morning, September 5 and traveled to his apartment Walnut Creek, California, arriving at 4:00 p.m. He retired for the evening at 9:00 p.m. He arose the following day, Monday, September 6 at 4:15 a.m., arrived at work by 5:20 a.m., worked until 6:00 p.m. and retired for the evening at 9:00 p.m. He awoke the following day, Tuesday, September 7 at 4:15 a.m., arrived at work by 5:20 a.m., worked until 6:00 p.m. and retired for the evening at 9:30 p.m. On Wednesday, September 8 he arose at 4:15 a.m., arrived to work by 5:20 a.m., worked until 6:00 p.m. and retired for the evening at 9:00 p.m. On Thursday, September 9 he arose at 4:00 a.m., arrived at work by 5:05 a.m. and worked until 10:00 p.m.

At the time of the accident he had been awake for about 14 hours, 11 minutes and had been on duty for about 13 hours, 6 minutes.

## 2. Medical Factors

a. *Toxicology.* After the accident PG&E arranged to have a total of 4 employees undergo postaccident toxicological testing pursuant to Department of Transportation, Pipeline and Hazardous Safety Administration (PHMSA) regulations at 49 Code of Federal Regulations (CFR) 199.105 for drug testing and 49 CFR 199.225 for alcohol testing, respectively.<sup>4</sup> Testing was

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<sup>2</sup> The GSO provided written responses to written questions posed about his work/rest information and other Human Performance oriented questions that are contained elsewhere in this report.

<sup>3</sup> Similar to the GSO above, the GSOMC provided written responses to Human Performance oriented questions.

<sup>4</sup> Although regulated by the California Public Utilities Commission, PG&E adheres to postaccident toxicological protocol consistent with PHMSA regulations found at 49 CFR 199.

conducted for ethyl alcohol and illegal drugs, which included cannabinoids, cocaine metabolites, opiates, amphetamines and, phencyclidine. The results were negative for the presence of alcohol and the aforementioned drugs. Copies of the final toxicological testing results obtained from PG&E will be placed in the For Official Use Only (FOUO) portion of the docket maintained by the NTSB.

A summary of the toxicological test results is shown below.

<u>Position</u>	<u>Specimens obtained</u>	<u>Time/date collected</u>	<u>Results</u>
GCT	breath	3:10 a.m./9/10/10	negative
	urine	3:36 a.m./9/10/10	negative
AGCT	breath	4:29 a.m./9/10/10	negative
	urine	4:48 a.m./9/10/10	negative
TSF	breath	3:51 a.m./9/10/10	negative
	urine	4:14 a.m./9/10/10	negative
PG&E Contractor	breath	5:02 a.m./9/10/10	negative
	urine	5:21 a.m./9/10/10	negative

### 3. Operational Factors

#### *a. Training.*

PG&E provided each employee with numerous training sessions. The total number of training sessions for each employee is addressed in the following paragraphs. However, for the purposes of this factual report, only pertinent job-specific sessions will be addressed.

(1). The GCT on duty at the Milpitas terminal at time of the accident. The GCT took and passed a total of 171 training sessions. Pertinent job-specific training items include the following:

<u>Course</u>	<u>Date</u>
Refresher gas clearance process training <sup>5</sup>	8/10/2010
Gas clearance process training <sup>6</sup>	4/22/2009

<sup>5</sup> Refresher training for gas clearance process training identified elsewhere in this report.

<sup>6</sup> An 8 hour instructor led clearance training class that involves clearance and gas system terminology, identification of

Gas clearance process initial training W <sup>7</sup>	4/13/2009
Gas clearance process initial training <sup>8</sup>	4/13/2009

(2). The AGT on duty at the Milpitas terminal at the time of the accident. The AGT took and passed a total of 169 training sessions. Pertinent job-specific training items include the following:

<u>Course</u>	<u>Date</u>
Gas clearance process initial training	9/29/2009

(3). The TSF on duty at the Milpitas terminal at the time of the accident. The TSF took and passed a total of 171 training sessions. Pertinent job-specific training items include the following:

<u>Course</u>	<u>Date</u>
Gas clearance process initial training	11/19/2009

(4). A PG&E contractor on duty at the Milpitas terminal at the time of the accident.

PG&E records disclosed no training record information for the contractor.

(5). The GTC on duty at SCADA center in San Francisco, California. The GTC took and passed a total of 56 training sessions. Pertinent job-specific training items include the following:

<u>Course</u>	<u>Date</u>
Gas clearance process initial training W	2/24/2009
Gas clearance process initial training	2/24/2009
Gas clearance process training	2/19/2009

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isolation points, clearance point tagging, clearance process, clearance writing and a table-top exercise. To receive credit, an employee must receive a minimum score of 80% on a final written examination. This training is required for employees who actively participate in gas clearance.

<sup>7</sup> According to PG&E, this training is a duplicate of gas clearance process initial training identified elsewhere in this report.

<sup>8</sup> Computer based training that provides an overview of clearance and gas system terms, identification of isolation points, and the clearance process. This training is a prerequisite for gas clearance process training.

(6). The SGTC on duty at the SCADA center in San Francisco, California. The SGTC took and passed a total of 59 training sessions. Pertinent job-specific training items include the following:

<u>Course</u>	<u>Date</u>
Gas clearance process training	11/6/2009
Gas clearance process initial training W	2/24/2009
Gas clearance process initial training	2/24/2009
Gas clearance process training	2/19/2009

(7). The GSO on duty at the SCADA center in San Francisco, California. The GSO took and passed a total of 76 training sessions. Pertinent job-specific training items include the following:

<u>Course</u>	<u>Date</u>
Gas clearance process training	4/7/2009
Gas clearance process initial training W	3/29/2009
Gas clearance process initial training	3/29/2009

(8). The GSO on duty at the SCADA center in San Francisco, California. The GSO took and passed a total of 104 training sessions. Pertinent job-specific training items include the following:

<u>Course</u>	<u>Date</u>
Gas clearance process training	4/17/2009
Gas clearance process initial training W	2/27/2009
Gas clearance process training	2/27/2009

(9). The GSOMC on duty at the SCADA center in San Francisco, CA. The GSOMC took and passed a total of 86 training sessions. Pertinent job-specific training items include the following:

<u>Course</u>	<u>Date</u>
Gas clearance process training	3/2/2009
Gas clearance process initial training W	2/23/2009
Gas clearance process initial training	2/23/2009

*b. Experience.*

(1) The GCT on duty at the Milpitas terminal at time of the accident. Records revealed that the GCT was hired on December 26, 1984.

*Disciplinary action.* PG&E files disclosed no disciplinary actions pertaining to the GCT.

(2) The AGT on duty at the Milpitas terminal at the time of the accident. Records revealed that the GCT was hired on June 25, 2003.

*Disciplinary action.* PG&E files disclosed no disciplinary actions pertaining to the AGT.

(3) The TSF on duty at the Milpitas terminal at the time of the accident. Records revealed that the crew leader was hired on January 24, 1972.

*Disciplinary action.* PG&E files disclosed the following disciplinary action pertaining to the TSF:

1. On May 20, 2010 he was issued a written reminder for using a drill on an object that was not secured, resulting in a "self injury."
2. On April 15, 2009 he was given coaching/counseling for going on a roof with improper personal protective equipment (PPE).
3. On February 19, 2009 he was issued an oral warning for improper use of equipment (no further information).

(4) The contractor working at the Milpitas terminal at the time of the accident. Records revealed that a contractor employed by PG&E was hired on April 1, 2004. He had previously been employed with PG&E from January 6, 1969 until his retirement as a gas engineer on March 31, 2004.

*Disciplinary action.* PG&E files disclosed no disciplinary action pertaining to the contractor.



(5). The GTC working at the SCADA control center at the time of the accident. Records revealed that the gas transmission coordinator was hired on November 18, 2004.

*Disciplinary action.* PG&E files disclosed no disciplinary action pertaining to the GTC.

(6). The SGTC senior coordinator working at the SCADA control center at the time of the accident. Records revealed that the SGTC senior coordinator was hired on January 22, 1979.

*Disciplinary action.* PG&E files disclosed no disciplinary action pertaining to the SGTC.

(7). The GSO working at the SCADA control center at the time of the accident. Records revealed that the GSO was hired on December 8, 1983.

*Disciplinary action.* PG&E files disclosed no disciplinary action pertaining to the GSO.

(8). The GSO working at the SCADA control center at the time of the accident. Records revealed that the GSO was hired on June 18, 1979.

*Disciplinary action.* PG&E files disclosed no disciplinary action pertaining to the GSO.

(9). The GSOMC working at the SCADA control center at the time of the accident. Records revealed that the GSO was hired on September 17, 1974.

*Disciplinary action.* PG&E files disclosed no disciplinary action pertaining to the GSOMC.

#### 4. Interviews

With the Operations group and selected party spokespersons, the Human Performance group conducted interviews of PG&E personnel who could provide information pertinent to the investigation. The following is a summary of those interviews produced in the context of Human Performance areas of consideration. Complete transcripts of these interviews are in the public docket.

(1). The GCT on duty at the Milpitas terminal at time of the accident. The GCT said that his normal work hours were from 6:00 a.m. until 4:30 p.m., however on the day of the accident he remained at work beyond his normal shift.

When asked about his health, the GCT said, "It's pretty good. No major health problems." His most recent physical examination before the accident had occurred in April 2010. The GCT said he began using reading glasses about 3 months before the accident, and that otherwise his vision was fine. With regard to his hearing, he said he has it checked once annually; there were no

problems.

When queried about his workload on the day of the accident, the GCT responded, "It was actually pretty low that day." Other than a problem associated with a UPS, he denied additional problems with any equipment. He said he was not distracted or preoccupied while performing his duties, nor to his knowledge were any of his co-workers. He added there was no deadline for completing any task.

When questioned as to whether he underwent postaccident toxicological testing, the GCT responded that he provided a breath and urine specimen between about 1:00 a.m. and 2:00 a.m. the following morning, Friday, September 10.

(2). The AGT on duty at the Milpitas terminal at the time of the accident. The AGT reported that his health was good. He was unable to recall the date of his most recent physical examination. He stated he did not have any problems with either his vision or his hearing. When asked to characterize his workload on the day of the accident, the AGT responded, "On that day, it was between normal and low." He denied problems with any equipment. He said he was neither distracted or preoccupied from performing his duties, nor to his knowledge were his co-workers.

When questioned as to whether he underwent postaccident toxicological testing, the AGT said he provided a breath and urine specimen between 3:30 a.m. and 4:00 a.m. the following day, Friday, September 10.

(3). The TSF on duty at the Milpitas terminal at the time of the accident. The TSF said that on the day of the accident his crew consisted of himself and the AGT; later in the day the GCT and the PG&E contractor had arrived. He said that at some point pressure displays for the gas were lost, and that he didn't know why that occurred. The TSF said the crew continued to troubleshoot the problem until about 4:30 p.m. when the power was lost to the control unit located at Milpitas. He said that the GCT subsequently communicated via telephone with gas control operations<sup>9</sup> in San Francisco.

The TSF reported that his health was good, and that his most recent physical examination was within 1 year of the accident. The TSF said that he wears reading glasses, and that otherwise his vision was fine. With respect to his hearing, he said that he had very little hearing remaining in his left ear, and that his right ear was fine.

When asked to characterize his workload on the day of the accident, the TSF said his crew had planned well to perform their work for the day. He stated that he was neither distracted or preoccupied from performing his duties, and added he was not aware that any other member of the crew being distracted or preoccupied. The TSF said that other than problems affiliated with the UPS at the terminal, all other equipment functioned fine.

When questioned as to whether he underwent postaccident toxicological testing, the AGT said that he had provided a breath and urine specimens at approximately 2:00 a.m. the following day, Friday, September 10.

(4). The PG&E contractor on duty at the Milpitas terminal at the time of the accident. When questioned about his health, the contractor responded, "I would say my health is generally good." He recalled that his most recent physical examination before the accident occurred in either late 2009 or early 2010, and that his physician noted no problems, and that "everything was good." With regard to his vision, he said he had LASIK surgery about 3 years before the accident, and that

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<sup>9</sup> This location in San Francisco also houses the Supervisory Data and Control Acquisition (SCADA) equipment.

there were no problems with his vision. When queried about his hearing, he said that on occasion he sometimes has to strain to hear, and added "It's just probably not optimal," and "I can hear just fine."

When asked to characterize his workload on the day of the accident, the contractor responded, "Nothing out of the ordinary," and added it was a regular day. Aside from the problem with the UPS, the contractor said all other equipment functioned properly that day. He said he was neither distracted or preoccupied from performing his duties; he also stated that to his knowledge neither were any of his co-workers.

When questioned as to whether he underwent postaccident toxicological testing, the contractor said he provided a breath and urine specimens at approximately 4:30 a.m. the following day, Friday, September 10.

(5). The GTC on duty at the SCADA center in San Francisco, California. The GTC stated that his overall health was good, and that his most recent physical examination before the accident occurred in either late 2008 or early 2009; no problems were noted by his physician other than a need to lose some weight. He said that there were no problems with either his hearing or vision.

When asked to characterize his workload on the day of the accident, the GTC stated it was an average day. He added he was not distracted or preoccupied from performing his duties, and that there were no problems with his equipment.

(6). The SGTC on duty at the SCADA center in San Francisco, California. The SGTC said that his overall health was fair. He recalled that his most recent physical examination before the accident was in either December 2009 or January 2010. The SGTC said that both his hearing and vision were fine, and that he had used reading glasses for the past 15 years.

When the SGTC was asked to characterize his workload on the day of the accident, he responded that it was a typical day and that nothing unusual happened until the accident. He also said he was not distracted or preoccupied from performing his duties, and that there was no equipment malfunctions.

(7). The GSO on duty at the SCADA center in San Francisco, California. The GSO reported that his overall health was good, and that his most recent physical examination before the accident occurred during the spring of 2010.

(8). The GSO on duty at the SCADA center in San Francisco, California. The GSO said that his overall health was good, and that his most recent physical examination before the accident was in June 2010.

When asked to characterize his workload on the day of the accident, the GSO responded that it was an average, busy weekday shift. He said that other than losing SCADA at Milpitas he experienced no problems with any of his equipment. The GSO also said that he was not distracted or preoccupied from performing his duties up until the time of the accident.

(9). The GSOMC on duty at the SCADA center in San Francisco, California. The GSOMC described his health as good. The GSOMC said that with regard to his vision he wore reading glasses only, and that he had no problems with his hearing.

The GSOMC reported that other than a failed remote terminal unit, he experienced no other problems with any equipment on the day of the accident. He characterized his work day as normal until the problem at Milpitas had occurred, (his reference to losing SCADA). The GSOMC

reported that he was not distracted or preoccupied with anything that would have interfered with his ability to perform his duties.

Compiled by: /s/ \_\_\_\_\_  
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Date: February 2, 2011

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Acting Chief, Human Performance and Survival Factors Division (RPH-40)

Date: February 2, 2011