United States Department of Agriculture
Forest Service

Accident Investigation Report

Near Miss Resulting in Facial Second Degree Burn
Mark Twain National Forest, Salem Ranger District, Camden Fire location
Eastern Region
Salem, Missouri

March 23, 2006

Final copy __1__of__1__

Accident Investigation Report

Accident: Near Miss—Facial Burn

Location: Salem Ranger District, Camden Fire Location

Date: March 16, 2006

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Signature Date

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Note: Pages renumbered in redacted version and are not reflected above

FACTUAL SECTION

Sequence of Events

The fire was first observed around 0800 by a Salem Ranger District employee on his way to work. He mentioned it upon his arrival. A decision was made not to respond due to the frequency of private land fires in the area and the apparent low level of fire activity. The Forest often relies upon private citizens to report fires on National Forest land rather than respond immediately to the fire scene. The fire was also observed from the Marcoot Tower in the morning and determined to be low activity and on private land. By 1300 fire activity had picked up, the fire had moved onto federal land, and initial response action began. The Marcoot Tower is only staffed intermittently, depending on fire danger.

The timber marking crew was dispatched while the dozer operator and line scout drove together to the fire and conducted preliminary scouting and size-up of the fire. Initial attack resources met at the end of FR 2620 at the turnout. Initial attack resources consisted of an Incident Commander Type 4 (ICT4), a dozer with initial attack dozer operator (DZIA), a dozer swamper, a line scout, firefighter (Fftr) D assigned to burning out, and firefighters (Fftrs) A (FFT2 qualified), B (FFT2 qualified), and C (FFT1-trainee) assigned as holding crew for a burnout operation.

The dozer bladed a line around the vehicles parked in the turnout to create a safety zone. Past the turnout FR 2620 narrowed into an old woods road along the ridge-top. The dozer top-bladed the woods road, as it approached closer to the fire, to improve it as an escape route.

The ICT4 gave a briefing, identifying safety zones (the vehicle safety zone and the black) and the escape route back to the vehicles (along the bladed woods road). The red flag warning was mentioned and general strategy and tactics explained.

The DZIA proceeded north down the old woods road along the ridge, blading along the way, toward the private property line to the north to anchor into a green field. Once anchored, the plan was to bring the plow line up, burn out, and hold the line as they progressed around the fire.

Working his way in, the DZIA saw the fire had crossed the woods road ahead of him to the north. The DZIA identified a suitable drainage on the leeward side of the road, to the east, to construct the control line. He then backed up the ridge along the bladed road for approximately 50 feet, dropped his plow, and began plowing a line along the bottom of the drainage, roughly paralleling the ridge. He constructed line towards the north, anchoring to the green field with the intent of improving the line on the way back up.

The ICT4 instructed Fftr D to burn out behind the dozer and Fftrs A, B, and C to hold the line for Fftr D. Fftrs A, B, and C waited near the crest of the ridge for the dozer to plow up. They would then drop downhill and together with Fftr D commence burning out. Fftr C parked the ATV near the junction of the plow line and the ridge woods road.

While they waited, Fftr A told Fftr C he would look for spots and walked back a short distance (50 to 100 feet) to the south along the bladed escape route where he located several small spot fires ahead of the fire front and proceeded to line around them. Fftr A felt that the spots required additional help and called for Fftr B to come assist him. A Fireline in the vicinity of the spots had not yet been established.

The DZIA heard the radio talk about the spots and responded to not worry about them, that he would line around the leeward side of the ridge and catch the spots as he plowed upward. It is not clear whether Fftrs A and B heard this transmission.

Fftr C noticed the fire activity intensifying and went to move the ATV out of the fire's path, near the point where the plow-line began at the ridge. Arriving at the ATV, Fftr C saw that fire activity was increasing toward Fftrs A and B and radioed to the two that they needed to get out of there. Fftr C again radioed Fftrs A and B to move out.

Fftr A told Fftr B to "bail" (go to the safety zone). They had been working opposite sides of the same spot, with Fftr B to the south and Fftr A to the north.

Fftr A and Fftr B retreated in opposite directions; Fftr A retreated north along the bladed escape route toward Fftr C and the plow-line, feeling his escape to the south was compromised, while Fftr B retreated south along the escape route toward the vehicle safety zone.

While retreating through a smoky, hot area, Fftr A used a neck shroud and gloved hands for face protection and tried to avoid inhaling. En route, Fftr A felt a hot blast on his left side, from the west. After a very short distance, he reached clearer air, saw Fftr C, and walked towards Fftr C and the plow line.

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Upon reaching Fftr C, Fftr A noticed facial skin sensitivity. Fftr A continued to work on the fire, not meeting with the ICT4 until approximately 1530. The ICT4 told Fftr A to inform him if he began to feel worse.

Fftr A stayed on the fireline until released later in the day. Fftr A then noticed a blister on his nose. Fftr A completed a CA-1 and notified his immediate supervisor toward the end of the day. The ICT4 became aware of the extent of the injury and the CA-1 when he returned to the office later that evening.

Fftr A suffered second degree burns around his nose due to "a blast of heat" from the flaming front.

Environmental Factors

Area description: The Camden fire was located on the Salem Ranger District, Mark Twain National Forest, at T34N, R2W, sections 31 and 32. The fire was 196 acres, between the Bucksnort Fork and the East Fork Huzzah Creek drainages.

The topography at the fire location is characterized by long, gently sloping (5%) ridges bisected by an intermittent drainage and branches with side slopes of around 30%. The drainage pattern flows generally to the northwest, with all aspects present inside the fire perimeter. Foot travel is relatively quick.

Vegetation: Vegetation consists of upland oak and short leaf pine species, with white oak as a major component. Also occurring in lesser amounts was scarlet oak, black oak, and short leaf pine. A minor component of eastern red cedar was also noted. Tree size ranged in a mix of sapling and pole-sized stems to larger dominant trees, averaging around 14 inches.

Fuel conditions/weather: The area has had only limited recent fire activity (along the east slope near the field) but exhibited evidence of fire with regular frequency. Only minor snowfalls have occurred since leaf-drop, with the oak leaf litter retaining much of its loft (fuel model 9).

The Forest has experienced a long-term moisture deficit, with unseasonably warm winter temperatures. The Sinkin FTS weather station (236403) is located approximately 20 miles to the south of the fire location. Since March 1st, that station received precipitation on March 4th (.07"), March 5th (.29"), March 8th (.01"), March 9th (1.34"), March 10th (.11"), March 11th (.21"), March 12th (1.13"), and March 13th (.09"). The precipitation from March 9th to March 12th supplied the bulk of wetting, totaling around 3 inches. After those rains, the area experienced quick surface drying, with a minimum relative humidity of 35% on March 13, 30% on March 14, 15% on March 15, and 17% on March 16. Temperature maximums ranged in the fifties to sixties for that period.

This weather resulted in quick surface drying of the litter fuels. Post-fire examination of the site found that much of the sub-surface litter material and 100 hour fuels remained unburned. Notably, large diameter fuels were at least partially to completely consumed. These results reflect the long-term drought conditions, the rain events noted, and the more recent quick drying trend.

The National Fire Danger Rating System (NFDRS) for the Sinkin station forecasted a burning index (BI) of 43, an ignition component (IC) of 28, with an adjective rating of Very High. The observed indices resulted in a BI of 47, an IC of 57, with an adjective rating of Very High. The 2004 pocket card for the Mark Twain indicates that the BI was near the maximum for that date and the local watch-out thresholds for wind and relative humidity applied.

The fire weather forecast for March 16, issued at 04:26 out of the Springfield Missouri National Weather Service (NWS), noted in its discussion that "there will be a heightened fire danger today as relative humidity falls to 25 to 30 percent and west (W) to northwest (NW) winds gust to over 20 mph at times." The zone-specific forecast called for mostly clear conditions, with thunderstorms, a 20% chance of precipitation, a high temperature of 58-62, a minimum relative humidity (RH) of 32-37%, 20-foot winds in the morning out of the southwest (SW) at 11-15 mph, shifting in the afternoon to winds out of the NW at 14-18 mph, with peak gusts of 25-29 mph. Wind shift time to the NW was at noon, with precipitation amounts forecasted at .01 inch. Haines index was predicted at 5.

The station issued a red flag warning at 12:09, in effect March 16 until 19:00. That stated "conditions ahead of a cold front that will move across the region today will allow winds to gust to near 30 mph with sustained winds around 20 mph. This...in conjunction with relative humidity in the mid to upper 20 percent range will create conditions favorable for extreme fire danger." The station followed with an updated fire weather forecast that included the red flag warning, forecasting the chance of precipitation at 10%, high temperatures of 60-64, minimum relative humidity of 25-30%, 20-foot winds from the west at 11-15 mph in the morning and from the NW at 18-22 mph in the afternoon, with peak gusts of 25-29 mph, Haines index of 5. The NWS issued additional updates at 14:07 for the period beginning in the night and again at 20:46.

The Sinkin FTS station, from the period of 13:00 to 14:00, reported a temperature of 68-69, a relative humidity of 15-17%, winds out of the SW at 7-12 mph, with gusts 22-25 mph, and fuel moistures at 8.2 to 8.4%. The calculated BI was 42 to 45.

The submitted fire Incident Organizer noted winds NW 10-12, with gusts at 20 mph. An on-site observation at 16:00 noted eye-level winds at W-NW, a temperature of 69, with a relative humidity of 20% and clear skies.

Fire Behavior: The spot fires were located at the head of a small tributary (upper draw) of the main interior drainage. This was the site of relatively intense surface burning, as indicated by the char heights on tree stems (4- to 6-foot average, with many over 10 feet in height). Given the char patterns in that area, it appeared that this headfire approached the road from the drainage and was the source of the spotting across the road. It was estimated by on-site personnel that spotting distance was around 100 yards, given where they estimated the main fire to be at the time of spotting. It was also noted that as the main fire approached the ridge from the northwest, the flames were a broad sheet along the surface and that the fire came up to the ridge from the northwest very quickly, indicative of topographically and wind influenced fire behavior with dry surface litter fuels.

Just north of that location, the fire moved towards the area of intensity to the south. The road slope, north to south along the ridge was approximately 5% and the down-slope in the draw was approximately 30%. Char on the east side of the road/ridge was less, ranging from 1 to 4 feet. On-site personnel observed much less fire intensity there ("creeping down slope"), with moderate intensity generated by the burnout.

The observed on-site wind direction was aligned with the major drainage in the burn. Earlier, personnel scouting the fire had not noted any unusual fire behavior, with reports of "creeping" fire. The dried litter surface; very low relative humidity; and strong, aligned, gusty winds quickly moved fire upslope through the draw. It drafted with the spot fires, toward the location of the holding personnel, with intense unexpected fire behavior. This likely drafted fire toward the south along the ridge to that site. Conditions were very smoky at the time and visibility poor. Firefighter A stated that he thought the area continued relatively flat; he was not aware of the head of the drainage to the northwest, which produced a chimney effect.

Human Factors

The ICT4 drove the dozer truck to the fire, which he reported was distracting because he was unable to use the travel time as a window to collect his thoughts.

The DZIA was viewed as the "go-to" person for instructions on the line by the holding crew; this was the person present and engaged in immediate tactical decisions.

The ICT4 had to choose between being on the line with the firefighters and staying with the vehicles to use the mobile radio for communications with Dispatch. He also felt it was necessary to stay at the vehicle safety zone to receive and brief additional initial attack resources. He stated he "felt like a yo-yo", bouncing back and forth between the vehicles and the line.

Fftrs A and B (both collateral duty firefighters) defaulted to Fftr C (primary fire, squad boss trainee) for direction on the line; however, no one was designated by the ICT4 to act as supervisor. Both Fftr A and B felt, however, that this supervision was an unstated understanding.

The ICT4 did not question or respond to the radio traffic between crew members; he was not on the line and did not want to "micromanage" activities on the line. The ICT4 had complete faith in his experienced and primary resources. The initial attack organization would reflect the IC and all six firefighters supervised directly by him.

Individuals involved reported different understandings of the primary and secondary safety zones. One of the identified safety zones was the black; however, no one scouted or communicated an escape route to the black.

The two firefighters working on the spots did not possess good situational awareness of what the main fire was doing, being surprised when the intensity picked up. The fact that they were working on the spot fires without a secured control line in place and the threat of unburned fuel between them and the fire reflected their level of awareness. The old woods road/ trail, which the DZIA initially bladed to open up the escape route, gave the confusing impression of serving as a control line.

Tactics normally utilized on the district are routine in their decision process.

Material Factors

The handheld radios were not offering reliable communications with Dispatch even though the repeater tower was within sight. This had been noted in a previously filed SAFENET concerning this same radio issue.

Fftr C brought an ATV down the trail for the line scout to use; however, the line scout never met with the Fftr to take the ATV. Protecting the ATV may have been a distraction.

All personnel had appropriate PPE and the PPE performed as designed.

MANAGEMENT EVALUATION SECTION

Definition
The Management Evaluation Section of the investigation report "…contains an executive summary and recommendations to prevent similar accidents" per chapter 1 of the 2005 Accident Investigation Guide.

Process
The Camden Investigation Team utilized data identified in the Factual Section, on site investigation and detailed interviews and document review to identify causal factors and provide a basis for analysis. The results of a concurrent peer review process unveiled additional factual information used in the investigation. The primary focus of the investigation is to understand the causal and contributing factors along with the lessons learned identified by the incident participants, their peers and management.

The goal is to help participants establish a sense of ownership and positively influence long term attitudes and behavioral changes that result in a safer working environment. The intent of this section is to provide a link between the Factual Section of this investigation report and the opportunities identified by those directly involved in the incident and their peers to prevent similar accidents.

When a fire fighter on the Camden Fire encountered a close call and partial entrapment that resulted in a minor injury, current CA-1 reporting protocol immediately brought the event to the attention of Forest and Regional management. Response to an accident or entrapment normally results in the region dispatching a Serious Accident Investigation Team, complete with a Delegation of Authority specifying the 2005 Investigation Guide protocols.

Launching a regional investigation concerning a minor injury, when no fire shelter was deployed reflects a growing management commitment to learning from close calls and not waiting for tragedy. Guidance and counsel related to close call reporting and inquiry emerges from Fireline and Incident Leadership Curriculum(s), After Action Review process, the Lessons Learned Center, contributions by High Reliability Organization advocates and Forest Service Fire doctrinal advice. It is safe to say that techniques applied by firefighters in southeastern Missouri are representative of many firefighters, and the holes discovered are challenges on a much broader scale.

The Camden Fire Investigation Team has met the accident investigation procedural and documentation requirements, while simultaneously involving participants in a "lesson's learned" exercise. This process meets the definition of the Management Evaluation Section. Networking among national fire operations safety council members facilitated this type of peer review process.

Executive Summary of Discussion and Recommendations

Salem Ranger District Employees participated together in a separate peer review process for identifying lessons learned and recommendations to change future outcomes. Specific recommendations did not always immediately surface, so some challenges were set forth to the group for further consideration. The investigation team built upon this to develop lessons learned and to gain further information on the incident.

Participants identified solutions to gaps between ideal fundamentals and current practice. The Camden terrain and situations were recreated and participants' relived, through a tactical decision exercise that explored decisions, options and opportunities available at the time. Firefighters were challenged to find strategies and tactics that would have prevented the close call. Some of the findings identified in the factual section were derived from the firefighters as they worked through this process.

The discussion followed LCES (Lookouts, Communications, Escape Routes, and Safety Zones) as an outline. LCES serves as a summary of the Ten Standard Firefighting Orders and Eighteen Watchout Situations (10 and 18) to facilitate the task of timely recall into critical lines of thought. The 10 and 18 must be considered both a process and a checklist. The order of the current 10 Standard Fire Orders correlate directly to the proper preparedness and fireline actions needed to safely participate in fire management activities. Along with the 18 Watchout Situations they also serve as a checklist to ensure proper and safe procedures are employed during these activities.

The 10 and 18 are correlated with Findings and discussion points for reference, noting which ones were compromised or overlooked. Standard Fire Orders and Watchout Situations not specifically mentioned received adequate consideration during the incident. Safety zones are discussed first.

Safety Zones

Safety zones were identified during the briefing. Individuals recognized two safety zones: the truck turnout and "the black". The dozer operator also recognized the green field serving as his anchor point as a safety zone. All individuals did not have the same perception of which was the primary safety zone and which was the alternate.

Individuals felt the truck safety zone was large enough for the fuel type. The peer review coach challenged the group to reconsider this. Rule of thumb for radiant heat is that the radius of the safety zone should be four times the anticipated flame length. A rule is not defined for convective heat.

Discussion ensued concerning the intent in using the black as a safety zone. The black needs to be "good" black, i.e., free from hazard snags and cold. The black is brought along with the line construction, so that there are not unburned fuels between the black and the control line. Everyone needs to be made absolutely clear about this. The best safety zone is "one foot in the black".

Standard Fire Order #4, "*Identify escape routes and safety zones and make them known*", was compromised to the extent that all were not clear on the primary and secondary safety zones. This is linked to Finding #19.

Lessons Learned:

1) **Communicate unequivocally the description and location of escape routes and safety zones and prioritize them, if more than one.**
2) **Designated safety zones need to be large enough to be effective.**

Lookouts

No one was specifically identified and posted as a lookout. Posting a designated lookout is not common practice in this area. The sentiment is that the terrain and fuels are unaccommodating and hinder the utility of a lookout. Instead, everyone relies upon each other to look out. For the dozer, his swamper/scout is doubling as his lookout. The sentiment expressed also is that if too many initial response resources are used as lookouts or non-fireline personnel, there won't be enough firefighters available to work the fire.

If people are expected to serve as lookouts for each other on the line, this needs to be elevated to a conscious level; define and express who is looking out for whom. Make it more formal. The quality of the lookout is based on the time it takes to get out the escape route. Every individual at times has lookout responsibilities.

The coach challenged the group to reconsider how they are applying the concept of a lookout. They need to modify and figure out how to post a lookout in low relief terrain and post a lookout every time.

Standard Fire Order #5, "*Post lookouts when there is possible danger*" and Standard Fire Order #2, "*Know what your fire is doing at all times*" were compromised. No lookouts were formally designated, yet the red flag warning indicated dangerous conditions. This links to Findings 23, 25 and Findings 12, 17, and 20 for Orders #5 and #2, respectively.

Watchout Situation #12, "*Cannot see main fire, not in contact with anyone who can*" links to Finding 17 and Watchout Situation #15, "*Wind increases and/or changes direction*" links to Findings 23 and 25. These tie in to the important functions of a lookout.

Lessons Learned:

1) **Identify who is looking out for whom on every fire.**
2) **Make sure each firefighter knows who their lookout is.**
3) **Make sure a designated lookout is not doing other jobs.**
4) **Make sure all firefighters are in communication with someone who can see the fire and are situational aware.**
5) **If too many firefighters are pulled into other roles to assure safety, withdraw until adequate resources arrive.**

6) **It's ultimately safer and more effective to have fewer firefighters available than to compromise safety for production by not meeting LCES standards, e.g., lookouts.**

Communications

Radio communications are an issue. The handheld radios could not communicate with Dispatch. This problem prompted the IC to stay with the vehicles where he relied on the mobile radios for communications. The IC found himself constantly trying to bounce back and forth from the trucks to the fire. This trickled down into inadequate leadership and direction on the fireline from the IC. This could be remedied by setting up a radio relay for the IC, either on-site or remote.

Standard Fire Order #7, "*Maintain prompt communications with your forces, your supervisor, and adjoining forces*" and Standard Fire Order #9, *Maintain control of your forces at all times*" were compromised by the ICT4's lack of presence on the fireline. This links to Findings 2, 10, 14, 18 and 22. Standard Fire Order #8, "*Give clear instructions and ensure they are understood*" is critical to maintaining command and control of fireline forces. This was further compounded by Firefighters B and C overlooking Watchout Situation #4, "*Unfamiliar with weather and local factors influencing fire behavior*" and Watchout Situation #11, "*Unburned fuel between you and the fire"* placing themselves in harms way. These link to Findings 20, 21, and 23 and Findings 12 and 21 respectively.

Lessons Learned:

1) **The initial attack IC needs to be present on the fireline to direct operations. If this is not possible, leadership needs to be appropriately delegated on the fireline.**
2) **Remedy inadequate radio coverage by designating a radio relay.**

Escape Routes

The escape route was designated as the bladed woods road; however, the fire ended up burning across it. Discussion elicited comments that the black could also serve as an escape route. There is a tendency to assume that everyone knows that when they "bring the black along" that it is an escape route/safety zone. Don't assume this; vocalize this concept every time.

The woods road used as an escape route crossed a saddle, which later funneled the fire. Under the current droughty conditions, recognize that acquired knowledge about fire behavior becomes obsolete. The coach challenged the group to think about this location.

The coach challenged the group to rethink their approach to fighting fire. Lost response time may be an acceptable alternative to approaching the intended anchor point from the head of the fire. This created the problem of putting firefighters, including the dozer, where there is unburned fuel between them and the fire, especially with a saddle present. The firefighters need to be sure they are bringing the black with them and don't veer from the anchor point prematurely.

Watchout Situation #3, "*Safety Zones and escape routes not identified*", was compromised in the sense that an escape route into the black was not identified. This links to Findings 19 and 24.

Lessons Learned:

1) **Scrutinize the location of the escape route so that it can safely serve its intended purpose. Be aware of conditions that may contribute to unexpected fire behavior.**
2) **Clearly define the meaning of "bringing the black along"—every time.**
3) **When unburned fuel exists between firefighters and the fire, there is a need for increased situational awareness, i.e., LCES.**
4) **Specifically identify the escape route into the black.**

Conclusion

The entrapment was caused by a number of causal and contributing factors. Standard Fire Order #10, "*Fight fire aggressively, having provided for safety first*" was compromised. This links to Finding #11, that the tactics used primarily focused on immediate fire suppression without due diligence to critical safety concerns and providing for firefighter safety first. Standard Fire Order #3, "*Base all actions on current and expected behavior of the fire*" was overlooked when initial attack forces tactics did not tactically react to the red flag warning and the predicted afternoon wind shift from the southwest to the northwest which aligned the winds with the local topography where the fire was located. While the resultant injury was minor, the investigation revealed that this could have easily been a serious injury. The findings demonstrate that this incident was preventable. The fact that the firefighters were operating on their home unit and using the same methodology that had worked in similar situations in the past appears to have led to complacency. Failure to adjust to a different set of circumstances and specific human factors contributed to this incident. In summary, Standard Fire Orders 2, 3, 4, 5, 7, 8, 9, and 10 were compromised. Watchout Situations 3, 4, 11, 12, and 15 appear to have also been overlooked. The Mark Twain NF Forest Supervisor is commended for requesting a regional level investigation to determine what happened and identify lessons learned. The Mark Twain NF employees involved are commended for their honest and straight forward participation in the Peer Review process that contributed to a climate and culture of identifying and implementing lessons learned in both the near and long term.

[1] STANDARD FIREFIGHTING ORDERS:
1. Keep informed on fire weather conditions and forecasts.
2. Know what your fire is doing at all times.
3. Base all action on current and expected behavior of the fire.
4. Identify escape routes and safety zones and make them known.
5. Post lookouts when there is possible danger.
6. Be alert. Keep calm. Think clearly. Act decisively.
7. Maintain prompt communications with your forces, your supervisor, and adjoining forces.
8. Give clear instruction and insure they are understood.
9. Maintain control of your forces at all times.
10. Fight fire aggressively, having provided for safety first.

18 WATCHOUT SITUATIONS

1. Fire not scouted and sized up.
2. In country not seen in daylight.
3. Safety zones and escape routes not identified.
4. Unfamiliar with weather and local factors influencing fire behavior.
5. Uninformed on strategy, tactics, and hazards.
6. Instructions and assignments not clear.
7. No communication link with crewmembers/supervisors.
8. Constructing line without safe anchor point.
9. Building fireline downhill with fire below.
10. Attempting frontal assault on fire.
11. Unburned fuel between you and the fire.
12. Cannot see main fire, not in contact with anyone who can.
13. On a hillside where rolling material can ignite fuel below.
14. Weather becoming hotter and drier.
15. Wind increases and/or changes direction.
16. Getting frequent spot fires across line.
17. Terrain and fuels make escape to safety zones difficult.
18. Taking a nap near fireline.