



Health Assessment of 2003 Al Mishraq Sulfur Fire Incident Status: July 2011 ‡

FACT SHEET 64-007-0711

Incident Summary: On 24 June 2003, a fire accidentally ignited at the Mishraq State Sulfur Mine Plant in Iraq. The fire burned for approximately three weeks, and a smoke plume was visible on satellite imagery for miles. The plume contained various contaminants including particulate matter and varying concentrations of sulfur dioxide (SO₂) and hydrogen sulfide (H₂S).



Satellite photos demonstrate that the smoke plume direction, length, and opacity varied throughout the three week time frame. Field sampling data collected by a preventive medicine detachment and anecdotal reports of odors and irritation suggest acute effect levels of SO₂ were not located solely in the immediate vicinity of the fire. On some occasions, acute effect levels were noted at the Q-West Air Base and Life Support Area, 25 kilometers (km) to the south. Satellite imagery shows some limited northerly movement of the smoke plume reaching approximately 50 km to the north up to the Mosul Airfield area. Though some anecdotal reports of odors suggest SO₂ may have reached this far, no field samples were collected from this area.

Personnel Exposures: Detected levels for SO₂ and H₂S from the 2003 sulfur fire are associated with effects ranging from minimal irritation/odor to more severe irritation, coughing and choking sensation. Specific exposure levels and durations experienced by individual troops are assumed to have been quite variable depending on an individual's location, activity, and the day/time. Given limited field sampling data combined with the lack of specificity regarding individual locations and activities during that time, there are no means to specifically identify individual exposures.

USAPHC assumed that the greatest overall exposures were to those assigned to fight the fire. During the initial response, personal protective equipment used by firefighters was likely inadequate against the levels of SO₂ and H₂S in the smoke. Some firefighters experienced irritation, minor burns and irritative effects such as blood-tinged nasal mucous, but no serious health consequences were recorded. A roster of 191 firefighters and support elements (such as medics) was prepared at the firefighting site. The roster identified individuals primarily from the 101st Airborne Division – the 52nd Engineer Battalion, 326th Engineer Battalion, and the 887th Engineer Company. While this roster may not have completely captured all firefighting personnel, it is believed to be a reliable indication of the majority of personnel involved in this activity. These personnel were medically evaluated and had an assessment of pulmonary function prior to leaving the site. No significant findings were noted.

Significant exposures to other Soldiers may have occurred. For example, troops were reportedly assigned missions such as securing the perimeter of the Mishraq Plant and/or evacuating local civilians in the area. Varying degrees of intermittent exposure could have occurred to personnel traveling along the main supply route, at Q-West Air Base and Life Support Area, or even the Mosul Airfield. Medical personnel at the Q-West Area reported approximately 20% increase in sick call visits during this time and noted that one asthmatic had an exacerbation of his condition.

Health Effects. Both H₂S and SO₂ are gases that can produce irritation of the eyes, nose and throat, and coughing. Because these gases are water soluble, they typically penetrate as far as the nose and throat with minimal amounts reaching the lungs unless the person is breathing heavily, breathing only through the mouth (both conditions potentially present with exertion, i.e., Soldier doing their job), or the concentrations are especially high, as was noted in some of the sampling. Information on the combined exposures to the gases is not definitive, though it is plausible that effects may be exacerbated. At high levels, SO₂ can react with moisture on the skin and in the lungs and cause irritation or even burns. Very high concentrations of SO₂ have caused severe airway obstruction, hypoxemia (insufficient oxygenation of the blood), pulmonary edema (a life threatening accumulation of fluid in the lungs), and death in minutes. Pulmonary edema may be delayed for hours or days. As a result of severe exposures, permanent lung injury may occur. Several human studies have shown that repeated, long term exposure to low levels of SO₂ has caused permanent pulmonary impairment. This effect is likely due to repeated episodes of bronchoconstriction. Sensitivity varies among people, however, so for some persons short exposure to even relatively low concentrations has been found to produce a reversible decrease in lung function and bronchial constriction. For example, asthmatics have greater susceptibility to effects at lower concentrations.

‡ This document updates the information in the previous 2007 USACHPPM Sulfur Fire Factsheet

Initial Evaluation of Long Term Health Implications: On return to Ft Campbell, preventive medicine personnel hypothesized that in addition to firefighters, there were thousands of other returning troops who may have been exposed to the plume that passed over the Q-west area. Post Deployment Health Assessment Forms (DD2796) from troops redeployed to Ft Campbell confirmed that there were numerous concerns regarding their sulfur fire smoke exposure. Soldiers with immediate health concerns were provided medical evaluations and offered a screening pulmonary function test (PFT). Soldiers with symptoms/abnormal PFTs were referred for further evaluation through the Blanchfield Army Community Hospital (BACH). Medical conditions that required further specialized assessment were referred to Vanderbilt Medical Center. In 2004, as part of its environmental medical surveillance mission, the USAPHC became aware of the screening process at Fort Campbell. At that time there were no clear indications of sulfur fire exposure-related health problems in the redeployed troops, although many of them were still in the evaluation process. The roster of individuals identified as present at the fire site had been provided to USAPHC for archival purposes. Utilizing this roster, the USAPHC obtained health outcome data to assess long term post deployment outcomes in this group. However, in 2007, the USAPHC became aware of a number of individuals who had been seen at Vanderbilt University Medical Center for shortness of breath with exertion. Based on this information, the USAPHC expanded its evaluation to include a group of over six thousand troops that are presumed to have been within 50km of the Mishraq State Sulfur Plant during the event, based on unit location information. This is considered a conservative yet representative cohort of those within the area of potential exposure. It is not a definitive group of persons with exposures to specific levels of concern. The analysis did not show a definite link between sulfur fire exposure in Iraq and either chronic or recurring respiratory diseases. However, the results do not rule out the possibility of such an association. Based on pre- and post deployment health assessments, a substantial proportion of troops with potential exposure to the sulfur fire reported health and exposure concerns. While those potentially exposed to the sulfur fire did not demonstrate increased respiratory conditions, it was noted that this group and the comparison group, are at increased risk of requiring clinical assessment or care for chronic or ill-defined respiratory conditions compared to their predeployment experience. (*U. S. Army Public Health Command Epidemiological Consultation No. 64-FF-064C-07, Mishraq Sulfur Fire Environmental Exposure Assessment.*)

More Recent Findings. Additionally, although not evident in the larger epidemiological analysis, from late 2004 through December 2009, 80 soldiers citing exposures to the sulfur fire or other inhalational exposures and reporting unexplained shortness of breath on exertion had been referred to and evaluated by a pulmonary specialist at Vanderbilt Medical Center. As of July 2011, 49 personnel had an open lung biopsy; all biopsy samples were abnormal. Of these, 11 were diagnosed with either sarcoidosis, respiratory bronchiolitis interstitial lung disease, hypersensitivity pneumonitis, respiratory bronchiolitis, or other diagnoses. 38 were diagnosed with constrictive bronchiolitis. Since December 2009, constrictive bronchiolitis has been diagnosed in an additional 9 soldiers in the study group. [King MS et al. *N Engl J Med* 2011; 365:222-30.] Further analysis of these findings is underway. Constrictive bronchiolitis is an inflammatory and fibrotic lesion of the terminal bronchioles of the lungs which is irreversible and difficult to treat. This diagnosis is very uncommon; however, it has been associated with inhalation exposures, organ transplantation, certain drugs, and collagen vascular disorders. Individuals with this finding typically have shortness of breath with exertion, but may have normal chest X-rays and inconclusive findings on pulmonary function testing which are done at rest. Due to some similarities, symptoms of constrictive bronchiolitis may be attributed to asthma or chronic obstructive pulmonary disease (COPD).

Current Conclusions and Recommendations: While individual exposure levels cannot be accurately determined, the USACHPPM currently considers constrictive bronchiolitis (initially diagnosed as "bronchiolitis obliterans") to be plausibly associated with exposure to the 2003 Mishraq State sulfur fire event. This health effect has been scientifically associated with very high exposures to SO₂. While personnel exposures varied considerably, individual risk factors or susceptibility may play a role. Due to limitations in the military deployment tracking databases used in 2003-2004, the actual cohort of all exposed persons is not definitively known. If sulfur fire exposures are related to constrictive bronchiolitis, it is possible that others in the area may have this outcome. Recommendations of the sulfur fire report included long-term follow-up of the cohort in the military health system, establishment of a registry, consideration of standardized medical evaluations of troops presenting with dyspnea on exertion and baseline pulmonary function testing on all Service members given the inhalation hazards encountered in deployed settings. Education of health care providers, including military, civilian, and Veterans' Administration physicians, was recommended to raise awareness about health effects associated with sulfur fire exposures.

If you have questions, concerns, or any additional information regarding this incident please contact:

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