Annex A
Bulk BW Agents

Background

Under UNSCR 687 Iraq was required to disclose all aspects of its weapons of mass destruction (WMD) program. However, four years passed before Iraq admitted it had an offensive BW program. ***Even after this, despite warnings about the consequences of not disclosing everything completely and truthfully from the UN, Iraq chose defiance. Iraq never disclosed the true amount of* B. anthracis *and probably other BW agents it had produced before 1992 as well as several locations where bulk BW agent was stored, and in one case, destroyed, according to multiple sources.*** UN inspectors on many occasions asked members of Iraq's BW program about additional storage sites, suggesting that they suspected, or knew of such a site or sites, but Iraqi officials persisted with their deceit until OIF and beyond.

ISG Investigation

Disparities in Declarations Concerning Pre-1992 *B. anthracis* Production

Information obtained by ISG from several sources with access to Iraq's former BW program and other related historical information show that Saddam's Regime probably did not declare the production of thousands of liters of *B. anthracis*. This information appears to support pre-OIF judgments made by the Intelligence Community and UN inspectors that Iraq did not disclose the total amount of BW agent it had produced, and therefore continued to be in violation of UNSC resolutions. Although ISG assesses there to be only a very small chance that Iraq kept some of this undeclared *B. anthracis* until OIF, ISG has been unable to obtain evidence to substantiate preservation or complete destruction of the agent.

- Iraq produced much more *B. anthracis* between 1989 and early 1991 than it declared to the UN, according to an individual that worked in Iraq's former BW program. This individual told ISG that approximately 550 kilograms (kg) of the peptone growth media Iraq declared as "lost" actually was used to produce the *B. anthracis* that was not declared. Enriched mediums, such as peptone were used by Iraq to produce seed *B. anthracis* for the bulk production process.

- BW agent production continued at Al Hakam until the day before the start of the first Gulf war in January 1991—contrary to Iraqi declarations, which stated that production ceased at the end of 1990—and the FMDV Plant was used to produce *B. anthracis*, according to an Iraqi formerly involved in biological agent research.

- UNSCOM found *B. anthracis* in two fermentors and a mobile storage tank at the FMDV Plant that was "consistent with the strain used in Iraq's BW program," according to an UNMOVIC document on Iraq's unresolved disarmament issues (UDIs) as of 6 March 2003. Two pieces of the equipment that tested positive were destroyed by UNSCOM in 1996, and subsequent sampling of the FMDV Plant in November 1996 did not detect *B. anthracis* on any remaining equipment.

- Iraq's Military Industrialization Commission (MIC) sequestered a portion of the production facility at the FMDV Plant from July 1990 until July 1991 for secretive work that emitted a smell of peptone two to three times a week, according to a current assistant manager of the FMDV Plant who has worked there since the early 1980s. ISG judges some of this secretive MIC work was the botulinum toxin production Iraq declared it produced at the FMDV Plant in November and December 1990; however, the continuous peptone smell outside of these dates fits with information from the individual that worked in Iraq's former BW program, who told us that the peptone declared as "lost" was actually used to produce more *B. anthracis* than was declared at both the FMDV and Al Hakam.

- UNSCOM and UNMOVIC could not verify the amount of BW agent Iraq declared producing because of discrepancies in its reporting of the amount of media and fermentor time available to produce the agent, according to the UNMOVIC document on Iraq's UDIs.

- Despite repeated attempts by ISG to confirm this information with interviews with key personalities who would be knowledgeable, no further information or physical evidence has been collected up to this point.

Undeclared Movement and Destruction of Bulk BW Agent

ISG has conducted a series of interviews and site visits to uncover more information on the movement and destruction of at least some bulk BW agent in 1991. When Iraq disclosed its offensive BW program in 1995, those involved decided not to disclose the movements and destruction areas associated with bulk BW agents.

- A scientist who worked for the former Iraqi Regime told ISG that Iraq destroyed three tons of *B. anthracis* at Al 'Aziziyah. ISG assesses that this three tons of *B. anthracis* only is a portion of that not declared to the UN.

- An assistant of Dr. Rihab told UN inspectors in early 1997 that he had taken an unspecified number of one-cubic meter tanks filled with *B. anthracis* into the desert north of Baghdad near An Nibai and dumped the agent there in July 1991, according to the Iraqi formerly involved in biological agent research.

- The chief reason offered for not declaring agent disposal at Ar Radwaniyah was fear of informing Regime officials that Dr. Rihab's BW staff had deposited deactivated *B. anthracis* and probably at least one other agent in an area surrounded by Special Republican Guard (SRG) barracks and within site of the Ar Radwaniyah Presidential Palace.

- How high up the chain of command this knowledge of undeclared movement and destruction went is yet to be determined. Evidence suggests that the Head of the Technical Research Center (TRC), Ahmad Murtada, the official responsible to Husayn Kamil for BW, knew, but he denies it. It has yet to be determined if 'Amir Al Sa'adi, Husam Amin, or the Vice President and the Higher Committee also knew.

This deception, in effect, prevented any possibility of the UN accepting the Iraqi account of its BW program. Whether those involved understood the significance and disastrous consequences of their actions is unclear. These efforts demonstrate the problems that existed on both sides in establishing the truth.

Annex B
BW Research and Development Facilities

Iraq's BW program was initiated in early 1974 in a house in Al 'Amiriyah, but soon after completion of basic buildings on a new site, Al Hasan's Ibn-Sina Center, or site number 2 (or later Al Salman) the program was transferred to Ibn-Sina Center mid 1974. This site was heavily bombed in 1991 and was effectively not functional after that time. After the initial construction of a clinic, telephone exchange in mid-peninsula, a bacteriology laboratory building which appeared to have functional high containment capability. On the back of this building was an attached animal house. Next in line was a virus laboratory, compartmented into 6 laboratories. This represented "Phase 1." Even before the transfer of the new BW program from Al 'Amiriyah, plans were already established for another facility (the green cube) "Phase 2" which became available about the same time as the dissolution of the original Al Hasan Institute. The remaining biology program along with elements of the CW program was then emplaced in this building as was the newly created Research and Technical Center (later to become the TRC). In the early 1980s Phase 3 was completed in the form of the Toxicology Laboratory to which the militarily relevant program was transferred in 1987.

Revitalization of Iraq's militarily relevant BW program was located at Al Muthanna from 1983 to 1987 when it was relocated to Al Salman. However, Al Muthanna continued to provide significant R&D assistance through 1990 particularly studies on aflatoxin and ricin as well as weapons field trials.

For many years, both before and following Desert Storm, the IIS conducted research and development of biological agents, such as ricin and aflatoxin, at several facilities discovered by ISG. Brief descriptions of these laboratories are presented below. The Al Safa'ah (AGRC), Al Salman and Al Muthanna sites were no longer functional after 1991 and thus further descriptions are not provided. Al Hakam, Al Manal, TABRC, Al Hamath, and the Al Tariq Company are deemed to have a significant post 1991 BW related capability and the descriptions follow. Baghdad University, College of Veterinary Medicine, al Razi Research Institute, al Kindi Veterinary Vaccines and Drug Company, Al 'Amiriyah Serum and Vacccine Institute have the facilities and expertise to play an important role in a resurgent R and D program.

Al Hakam

The Al Hakam facility was destroyed by the Iraqis under UNSCOM supervision in 1996 because of the discovery of the key role it played in the Iraqi BW program. Historically, Al Hakam was Iraq's primary BW agent production facility, producing *Bacillus anthracis*, *Clostridium botulinum*, *Clostridium perfringens* and simulant, *Bacillus subtilis*, for testing and ultimately, weaponization purposes. Following the first Gulf war, the Al Hakam plant was directed by Iraq to change its focus to civilian projects, which had been selected as a cover for its former BW program.

- The civil projects chosen to replace the production of BW agents and using the same equipment at Al Hakam were the production of biopesticides (*B. thuringiensis*), SCP and biofertilizers. The equipment at the facility was considered dual-use and the production of materials such as *B. thuringiensis* (a known stimulant for the BW agent *B. anthracis*) and SCP (whose equipment could be used to produce *C. botulinum*), led to the fear that Al Hakam could potentially be producing BW agent or at the very least, be maintaining the infrastructure and production expertise necessary to quickly reactivate Iraq's BW agent production capability.

Al Dawrah Foot and Mouth Disease Vaccine Plant

The FMDV plant was declared to UNSCOM as a facility that was used to produce botulinum toxin for offensive BW purposes from September 1990 until January 1991. After Iraq acknowledged its role in its BW program, UNSCOM disabled the FMDV plant's high containment air handling system in 1996 by pouring a mixture of concrete and foam into its ducting. No laboratory or production work is currently conducted at the FMDV plant. The plant is

currently being used as a central storage and distribution depot by the State Company for Veterinary Medicine. ISG has no information to suggest that the FMDV facility was involved in any BW-related research after the end of the first Gulf war in January 1991.

- Freezers were discovered by ISG containing hundreds of perished isolates of foot and mouth virus. The facility was also storing laboratory equipment from other facilities and archives from other veterinary institutes. No research or scientific activity was occurring at the facility.

- According to a source, the FMDV plant only produced vaccine up until 1990/91. The Main vaccine it produced was for Foot and Mouth Disease (FMD) Type 0 (for sheep). It also produced types A20 and Asia (for cows). The plant exported its FMD vaccine to 13 other countries in the region. From 1990-1991, MIC took over the FMDV plant. While the MIC was operating the facility, they gave the FMDV employees a small area in which to conduct work that was separate from MIC activities. None of the workers from the FMDV plant were said to have been brought in to help MIC. However, this is contrary to what was communicated to UNSCOM.

- Surveillance cameras were installed at the facility by UNSCOM in 1994/5 to monitor the activities at the facility until and following the removal and destruction of some key equipment. Cameras were also mounted in the plant's production department. Until some time prior to OIF, tapes were retrieved every two weeks by a local security company on behalf of the UN. The purpose of the cameras, after the building was rendered harmless in 1996, was to assure the equipment was not removed and installed at another location without proper notification to the UN.

Tuwaitha Agricultural and Biological Research Center

ISG investigated work into Bacillus thuringiensis and Single Cell Protein carried out at the TABRC. ISG exploited TABRC in 2003. During the exploitation, significant documentary evidence of ongoing research relative to Bt at TABRC and a number of equipment items which were capable of being used for production of small-to-pilot scale quantities of biological material. Numerous fermentors and bioreactors were found, some of which should have been reported to UNSCOM or UNMOVIC but were not. The underground storage of laboratory equipment was likely to protect that equipment from coalition bombing.

- TABRC was part of the IAEC within the Tuwaitha Nuclear Research Complex. Its mission was primarily agricultural science research and development, and the majority of its activities was directed toward crop improvement and integrated pest management. This facility possessed a mature scientific staff with expertise in recombinant DNA technology, microbiology, entomology, and access to agricultural pathogens. The center had research and development arrangements with other Iraqi biotechnology entities and possessed numerous pieces of equipment that could be used for either peaceful purposes or for development and production of BW agents (i.e., dual-use equipment). The facility was located within a high-security complex associated with other facilities of interest.

- ***ISG assesses that TABRC was not involved in any significant BW-specific activity. Work with Bt appears to have been laboratory scale only and primarily directed toward expanding the insect host range of Bt isolates.*** There was no evidence to support earlier ISG contentions that attempts were underway at TABRC to engineer *B. thuringiensis* to be pathogenic for humans.

- ISG conducted detailed site exploitations of TABRC over a period of several days. The determination was made that the site contained numerous pieces of UNSCOM-tagged equipment, as well as multiple pieces of undeclared equipment, that would be useful for BW agent production. The equipment ranged from a declared 750-liter double-jacketed stainless steel fermentor to an undeclared 5-liter fermentor. ISG found no information indicating any of this equipment was either intended or used for BW purposes.

Al Hamath

The Al Hamath facility was exploited on 19 April 03, which determined that the area was used for agricultural purposes and the activities assessed to have occurred at the site were determined not to be BW-related. The facility was heavily looted before it was exploited in April 2003. A local national at the site reported that the facility had been under military control and prior to UNMOVIC inspections the military had removed all the equipment from the site. Field laboratory analysis of samples taken from the barren facility also indicated no evidence of CW or BW related materials in the submitted samples. In 2000, TABRC began the construction of a pilot Single Cell Protein (SCP) plant at Al Hamath, located at the same site as the Official Rest House, to conduct larger scale SCP work. The project for the pilot plant scale production of citric acid had been started using *Aspergillus niger* but the project could not be made to work.

- The production method chosen was growth in submerged culture rather than in solid-state. Process equipment (e.g. mixing vessels, tanks, fermentation vessels) was commissioned and fabricated accordingly. The strain of *A. niger* used in this process proved unsuitable for use in submerged culture as the mycelium suffered damage under the continual stirring/agitation necessary in submerged culture. In short, the project could not be made to work. Having a collection of process equipment already in place at Al Hamath, it was seen as convenient to co-opt and reconfigure the equipment for SCP production.

- A source indicated that the SCP process was set up in the northeastern corner of the larger of the two main buildings at Al Hamath. The remainder of the space in the larger hall was devoted to the production of fungal biopesticides (e.g. *Paecilomyces, Trichoderma*) grown in solid-state culture on milled corncobs. The fermentations were conducted in the rooms (offices) pre-existing in that building.

Al Tariq Company's
Habbaniyah I/Fallujah III Site

The Al Tariq Company produced castor oil by extraction from 1992 until 2002, using an Iraqi-designed and produced crushing mill purchased locally. Al Tariq officials complied with UNSCOM on the requirement that they burn the bean mash left over from production while UN inspectors remained in Iraq. This open pit burning of mash was no longer observed after the plant was reconstructed, post-Operation Desert Fox bombing, and went operational. The mash, which took days to burn and created significant smoke, was burned in pits near the Fallujah III facility. At one point, Al Tariq officials considered using the bean mash in animal feed, but this idea was never implemented.

- Farmers at Al 'Aziziyah claim their land was taken by Husayn Kamil in 1994 or 1995 to be utilized as dedicated lands for the growth of caster plants, the end user of which was exclusively the Al Tariq facility. The MIC reportedly worked in collaboration with both the State Company for Industrial Crops and the Ministry of Agriculture to plant "cover crops" –other crops such as wheat-in order to mask the growth of the castor plants. In 2001, an employee of the Al Tariq Facility named "Husayn" told an individual at the farm that the castor beans were being used by the Al Tariq Facility in order to "produce poisons that would kill humans."

- Historically this site has been of concern because the castor oil plant could have potentially been used in the first step, mainly the castor bean mash, in the production of the BW agent Ricin. Iraq stated several different ways in which the ricin in the mash was being inactivated; yet UNSCOM showed that active ricin could readily be isolated from the mash after the castor oil was removed.

- During this time period, officials from Ibn-al-Baytar expressed an interest in purchasing castor oil from Al Tariq for use in pharmaceuticals. The Al Tariq facility's oil was not competitively priced, however, and because it was extracted by solvents instead of cold pressing, Al Tariq's oil was not considered to be "food grade", or appropriate for

medical/pharmaceutical uses. At one point, SDI purchased five tons of Al Tariq oil for pharmaceutical purposes, but upon sampling the oil, immediately deemed it as inappropriate for medical use and sent all of the castor oil back to Al Tariq. Because of these issues, Ibn-al-Baytar decided to procure castor beans directly from the same source as Al Tariq, the Company for Industrial Forests (CIF). After production ended in 2002, Al Tariq was left with unwanted castor oil, but no customers. The leftover castor oil was kept in barrels at Fallujah III.

During the work of the UN and ISG, a number of facilities have been identified as having carried out or have been assessed as capable of carrying out R&D on viruses. These facilities include the Al Kindi Company for Veterinary Vaccines and Drugs, the Al 'Amiriyah Serum and Vaccine Institute, the Al Razi Research Center, the Al Dawrah Foot and Mouth Disease Vaccine plant (before 1996 when UNSCOM disabled the air handling system), Baghdad University College of Veterinary Medicine at Abu Ghurayb and Al Hakam before its destruction (also in 1996). Al Hakam and Al Dawrah FMDV facilities are described above.

Al Razi Center

ISG determined that the Al Razi Center is no longer suitable for research or production of any biological activity because of extensive looting.ISG has no information to suggest that Al Razi was actively involved in R&D of viral BW agents for the Iraqi BW program. An ISG visit to Al Razi found numerous vials of lyophilized bacteria and yeasts that were littering the site including: *Vibrio cholerae, Salmonella typhi, Salmonella paratyphi, Clostridium difficile, Clostridium welchii, Saccharomyces cerevisiae, Brucella melitensis, and Brucella abortus*. In addition, numerous vials of lyophilized avian influenza were also noted.

Several burn piles consisting of burned documents, vials, chemicals, electronic media and small pieces of equipment where located around the building. The piles seemed to be an organized destruction effort given stir rods located with some of the piles.

An inventory of UNSCOM tagged equipment was conducted. Four pieces of dual-use laboratory equipment were noted missing.

ISG assesses that the research expertise available at the Al Razi center could potentially have been used to research viral BW agents.

- Al Razi was established in 1992 under the direction of Saddam Husayn. Dr. Hazim 'Ali, a senior personality related to the Iraqi viral BW program, and Athir Al Duri were responsible for setting up the facility with Dr. Hazim 'Ali in charge of the virology department and Al Duri director of the bacteriology department.

- The virology department at Al Razi was involved in work on Hepatitis and mumps diagnostic kits, using positive sera obtained from the Ministry of Health. The facility also had an animal house where they kept sheep, goats, rabbits and mice. No primates were seen by the source but monkey cages were seen in 1996 after a delivery from Al Muthanna.

Baghdad University, College of Veterinary Medicine, Abu Ghurayb

ISG found no information to suggest that the College of Veterinary Medicine, Baghdad University, played a role in the R&D phase of the viral BW program. ISG has uncovered no substantial connection between the BW program and the College of Veterinary Medicine.

- The College of Veterinary Medicine was capable of viral research. The faculty at the College of Veterinary Medicine possess the requisite knowledge and skill to grow and genetically manipulate potential BW agents. Based on the faculty's description of the equipment that was looted, the College had adequate resources to grow agents such as high-risk virus. However, the remaining equipment found in 2003 by the assessment team at the facility is inadequate to conduct any significant research or production of BW agents.

Al Kindi Company for Veterinary Vaccines and Drugs

All known UNSCOM tagged equipment at the Al Kindi Company for Veterinary Vaccines and Drugs was present at the site. The site is operating normally, although at a reduced level. A senior employee explained that they were still in the process of trying to reinstate the quality of their vaccines and had not yet developed elaborate plans for the future.

- Prior to Desert Storm, the facility was believed to be involved in Iraq's BW program. A foreign company supplied a complete vaccine production line in 1984 for the facility to produce "Co-Baghdad vaccine," a mixture of veterinary important Clostridial species. It was most of this vaccine line that was acquired by Al Hakam and used at that facility prior to 1991. Presently the company is able to produce viral disease vaccines for poultry to include: Newcastle, fowl pox, and gumboro; and viral vaccines for livestock to include rinderpest, sheep pox and goat pox. Bacterial disease vaccines include: enterotoxaemia (sheep), hemorrhagic septicemia, blackleg (*C. perfringens*, cattle), anthrax (sheep). Al Kindi Company did not sustain any damage during OIF, and no looting had taken place, since the employees stayed in the buildings and guarded them. No seed cultures were lost, since the company has generators that supplied power to the refrigerators and freezers without interruption.

- In April 1994, an UNSCOM Team found that the facility was the sole Iraqi producer of veterinary vaccines required to protect against animal viral, bacterial, and parasitic agents (including anthrax). However, a 1997 UNSCOM report indicated Al Kindi personnel had the expertise to run a BW production facility as well as apparent access to military significant microorganisms, and would have been able to easily convert veterinary vaccine production to production of human vaccines.

The Newcastle vaccine product lines at Al Kindi demonstrate an ability to scale up large quantity viral production. Al Kindi Company had the facilities that would enable mass production of smallpox virus in either cell culture or fertilized eggs, and in either liquid slurry or lyophilized form, however, no indication of intent to do so was found by ISG.

Role of Al 'Amiriyah Serum and Vaccine Institute (ASVI) in Smallpox R&D

ISG has uncovered no evidence to support smallpox R&D at ASVI for possible use as an offensive BW agent. The ASVI is the only facility in Iraq acknowledged to be associated with smallpox, albeit with the smallpox vaccine. The Institute continued to manufacture a smallpox vaccine through to the early 1980s.

ISG discovered no indications of BW activity at the facility. All equipment and material observed appeared related to serum and vaccine storage, quality control and very limited organic production capability. An ISG assessment on the facility states that it is unlikely that ASVI was involved in suspicious BW-related activities other than possible temperature control storage. Laboratory results from samples taken from the site were negative for BW agent signatures.

- ASVI produced limited quantities of bacterial and viral vaccines and diagnostic reagents and kits for human use. According to Hazim 'Ali, head of the Iraqi viral BW program, any smallpox isolates would have been stored at either the ASVI or the Central Public Health Laboratory. The director of ASVI stated, in a recent interview, that ASVI produced three and half million doses of smallpox vaccine in 1980, a month after the start of the Iran-Iraq war, eight years after the last smallpox case in Iraq and the year it was declared eradicated in the world. The director stated that vaccine might have been for defense against an Iranian BW attack, but it is also possible that the vaccine could have been a defensive measure for anticipated Iraqi smallpox use against Iran.

- From its inception, ASVI has not had the biosafety equipment, procedures or technical expertise to work with dangerous pathogens. Economic sanctions and import restrictions further impeded their ability to perform even basic research. In March 2003, the facility was extensively looted with reconstruction efforts at the facility focus on replacing air conditioning units, doors, windows and providing a consistent source of electricity. As of late August 2004, through its affiliation with a humanitarian organization, Kimadia State company for Marketing and Medical appliances, and the Iraqi

Ministry of Health, the facility was able to import small amounts of vaccine an other reagents. These were to be stored and later distributed by the facility.

- From 1975 to 1982, ASVI produced smallpox vaccine, utilizing the vaccinia strain; samples of the vaccine were cultured and collected from bovine calf skin. Production of smallpox vaccine was conducted under the auspices of the World Health Organization (WHO) from 1975 to 1977. The WHO vaccine was produced and stored in liquid form but between 1977 and 1980, ASVI also produced a powdered/lyophilized vaccinia product. In October 1980, ASVI requested Vaccinia seed stock from the WHO to produce more vaccine. The request was denied due to the disease having been eradicated, and the WHO ordered ASVI not to proceed with its vaccinia work but the Iraq Ministry of Health ordered it to produce the vaccine. By 1982, the viral research branch responsible for the smallpox vaccine, produced and subsequently stored, 3.5 million doses of the vaccine in liquid form. These samples were assessed to have a shelf life of three years. The remaining 750 grams of bulk smallpox vaccine preparation was stored in a powdered/lyophilized form. This preparation had a shelf life of 10 years.

- The vaccine produced as by ASVI in response to the request from the Iraqi Ministry of Health was manufactured by strengthening some vaccine it had previously produced and stored. The strain identified as having been used was Lister. The material was strengthened by three times inoculating rabbit skin and then infecting calf bellies. Each calf belly yielded about 200,000 doses of the vaccine. The scientist responsible for conducting the work left ASVI in 1982 and there were no tests of vaccine efficacy, such as neutralizing antibodies, in humans in Iraq. The 750 grams of material were tested in 1986 and found to be nonviable. In 1992, the 3.5 million doses of vaccine were tested and determined to be nonviable also. It was recommended that the vaccine be destroyed but ISG has been unable to confirm or deny this claim.

- In 1994, Iraq completed a WHO questionnaire regarding the reporting of smallpox vaccine production activities, vaccine stocks and seed virus strains. Their response indicated that ASVI maintained two smallpox vaccine seed vials that Iraq had obtained from the Netherlands before 1977 and 19 vials of *Brucella* antisera that had been produced in rabbits and mislabeled as vaccinia. In addition, a 1994 inventory submitted to the NMD listed the facility as possessing two vials of "smallpox seed No. Q1". During meetings with UNMOVIC in December 2002 regarding the 19 antisera vials and the two seed stock vials, Antoine Al Bana took one of the 19 vials for analysis and an UNMOVIC inspector also took one. Al Bana determined that there was nothing viable in the vial that he analyzed.

- Two vials of smallpox vaccine seed stock labeled "Rijks Instituut V.D. Volksgezondheid—10 ml seedvirus—L1 K2—Strain Elstree—Utrecht" were discovered at ASVI. These two large vials may be the seed vials referred to in the 1994 report to the NMD, however, SMEs note that the vials were markedly different in content and appearance. No locally produced vials labeled "Elstree" were discovered at ASVI. ISG is awaiting confirmation on the contents of these vials.

- According to a DGS intelligence officer who provided security at Rihab's laboratory at Al Salman and Al Hakam, an individual connected with ASVI in 1989 to 1990 had IIS connections and supported Rihab's BW efforts at Al Hakam. The individual had frequent contact with Dr. Rihab beginning in 1990. Rihab made frequent visits to Al 'Amiriyah Sera Vaccine Institute where she and the individual conducted unidentified BW related research. At ASVI, the individual source had access to special laboratories and conducted unspecified genetic research. The DGS officer stated that the source helped Rihab in her work. The DGS intelligence officer also stated that the source was an IIS officer and that his work was related to the IIS. When asked how he knew this he stated that Rihab was under constant surveillance by the IIS and that he learned the source's affiliation from other IIS officers. The individual left ASVI in 1991 to work at Baghdad University.

- All buildings, which were found to be heavily looted during April and May 2003, are now generally restored with equipment replenishment in progress. The UN tagged and untagged dual-use equipment found and the site were consistent with the declared purpose of the site.

State Company for Drug Industries and Medical Appliances

ISG exploitation of Samarra Drug Insustries' (SDI) location revealed industrial scale utilities and numerous, dual-use jacketed vessels, some of which had not been declared to the UN. ISG found no evidence that equipment at Samarra had been modified to serve as fermentors for BW production. ISG assesses, however, that the staff possessed the required expertise for bulk BW agent production and that Samarra potentially would have been capable of limited breakout production of BW agent within one month prior to OIF.

SDI belongs to the State Company for Drug Industries and Medical Appliances, which, in turn, is part of the Ministry of Industry and Materials (MIM) and under its direction and control. The main activities of the site are R&D and production and formulation of pharmaceutical products. A technical group within MIM provides guidance and direction for pharmaceutical compounds to be researched at SDI. Staff protected the plant post OIF and hence minimal looting took place.

- The facility appears to be producing its full product line except for antibiotics.

- Site buildings contain numerous jacketed process tanks ranging in capacity from 100–10,000 liters together with ancillary equipment such as filter presses, autoclaves and bio-safety cabinets. (Figures 4, 5, and 6)

- All equipment was assessed to be in good working condition.

- ISG judges that the 10,000-liter industrial scale tanks at Samarra are compatible with their declared use--the manufacture of pharmaceuticals—and that they would require considerable modification to function as fermentors for BW production. However, ISG also judges the 3,000-liter and possibly some or all of the 1,000-liter stirred, jacketed vessels could be pressed into service for BW production within one month.

- An ISG team was reluctantly admitted to a production hall containing tiers of linked, jacketed, stainless steel vessels, of Soviet origin, which were piped to receive steam. Some of these vessels were fitted with aeration rings and glass viewing ports but no stirrers/agitators were evident. (Figure 7) None of these vessels had been declared to the UN.

- The plant general manager asserted that these vessels were for solvent extraction of natural oils from plants, and that they were last used in 1975-76. ISG judges the vessels have a potential dual-use capability and that they could be adapted to function as fermentors for production of BW agents.

- High quality industrial scale steam and water utilities were available on site. (Figure 8)

Laboratories of the Iraqi Intelligence Service

ISG interviewed several sources and identified several suspect clandestine laboratories that reportedly supported biologically related research. ISG has not been able to determine whether these laboratories were part of a clandestine BW effort.

The tactic of using IIS and covert laboratories has historical precedence dating back to the programs origins in the 1970s. Reverting to this practice would minimize the evidence available to inspectors. It would also leave the known and acknowledged BW workers free to deal with the UN inspection regime. However, it would require another cadre of scientists other than ones known to the UN to conduct this kind of research. The discovery of multiple clandestine laboratories after OIF lends some credence to this assessment.

ISG found a possible DGS laboratory in Baghdad that contained a variety of chemicals but no laboratory equipment. Residents in the building alleged that the laboratory was a biological one. The investigating team found several DGS administrative documents, some of which were from employees requesting approval for danger pay for their hazardous work with biological and radioactive materials. This warehouse complex, adjacent to the 5-story IIS laboratory (site 5), was reported by a former mid-level IIS chemist to be a storage facility for IIS chemicals and equipment. A separate former IIS officer indicated this was a former IIS training facility and hide site; materials were reportedly moved from the IIS safe house (site 2) to this warehouse in the beginning of 2003 to avoid discovery by UN inspectors.

- During the first exploitation in April 2003, the exploitation team found large quantities of liquid and dry chemicals, equipment, documents, and other materials—some of which were partially destroyed. A visit to the site in July revealed a completely looted warehouse complex with no remaining evidence of chemicals, equipment, or documentation. A former IIS officer indicated that other IIS officers returned to the site in late April to destroy the remaining materials.

- Though not BW, ISG learned that the Chemical Preparation Division of IIS's M16 Directorate of Criminology used this approach for lethal chemical research. The IIS used a succession of four clandestine laboratories in At Taji and Baghdad between 1996 and 2003 to research and develop chemicals. It also included testing of chemicals on small animals like mice, rabbits and rats.

- There is information that suggests that up to 5 IIS laboratories operated in the greater Baghdad area at various times up until OIF.

- Additional reporting, though unconfirmed, indicates that the M16 Division also conducted BW related research in two covert laboratories as well. In the early 1990s, Saddam tasked the IIS to do small-scale BW work in covert laboratories concealed within legitimate facilities. Further unconfirmed reports indicated the IIS conducted BW and CW experiments and stored WMD precursor materials in residences and warehouse around Baghdad through April 2003.

- Information collected at the time of OIF led to the discovery of assorted laboratory equipment purportedly used by a suspect BW scientist on the Black List at a Mosque in Baghdad.

An ISG team at the Baghdad Central Public Health laboratory identified a clandestine laboratory in the summer of 2003. According to an employee of the laboratory, the IIS operated a laboratory at that location for several years. In advance of a 1998 UNSCOM inspection, secret documents were removed and stored at the Director's house. In December of 2002, the laboratory was emptied of all equipment and documents.

Figure 4. *Two 1,000-liter, stirred, jacketed vessels suitable for use as fermentors for the growth of bacterial BW agents.*

Figure 5. *Plate filter press.*

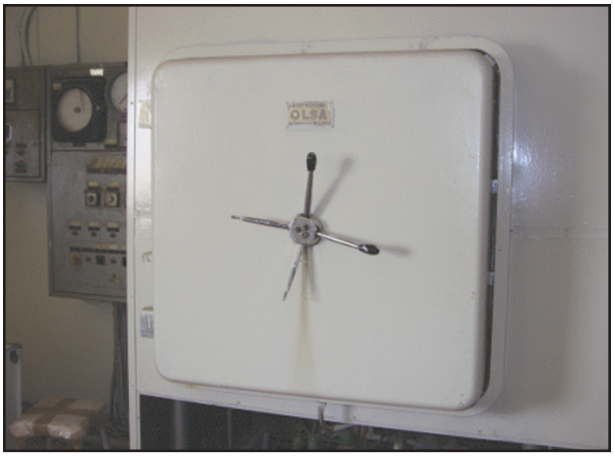

Figure 6. *Autoclave with control panel.*

Figure 7. *Production hall with tiered vessels of Soviet origin not declared to the UN.*

Figure 8. *High grade water production plant.*

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Annex C
ISG Investigation of Iraq's Reported Mobile Biological Warfare Agent Production Capability

Summary of Pre-OIF Intelligence on Iraq's Mobile BW Program

According to a chemical engineer whose reliability ISG now believes is highly questionable, Iraq developed a mobile BW capability designed to evade UN inspections and to provide Baghdad the ability to produce biological agents for offensive purposes. The chemical engineer stated that seven production units had been built, three of which had begun agent production runs. He identified six locations of the seven plants, as well as key engineers and personnel involved in the design, construction, and operation of the units (see Figure 1). Additional sources reported before OIF on the existence of a mobile biological capability in Iraq:

- An Iraqi civil engineer in a position to know the details of the program reported the existence of transportable facilities moving on trailers.
- An additional source reported that Iraq had manufactured mobile production systems mounted on road-trailer units and on rail cars.

Objectives of Investigation

Because Iraq's reported mobile BW agent production capability was a key element of the prewar assessment of Iraq's WMD programs, it was an important issue addressed by ISG, and the BW team tasked a variety of collectors and analysts against this intelligence issue with the intent to do the following:

- Locate and debrief Iraqis identified as being directly involved in the planning, design, manufacture, and operation of the BW agent production plants.
- Exploit the sites named as having an involvement in the program, as well as ancillary sites and companies connected to the cover story.

In the wake of ISG's investigation, ISG is unable to confirm the existence of a mobile BW agent production capability in Iraq. Key personnel in the mobile program were said to have been involved in both BW activities at Al Hakam and the design and construction of legitimate seed purification plants. Key findings include:

- All individuals that ISG questioned denied the existence of a mobile BW agent production capability.
- Individuals linked to sites that were part of the investigation deny that the sites were used by the military or intelligence services, or used to conceal specialized equipment, trucks, or railcars.
- Two key sites that reportedly housed production units bear physical features that ISG assesses prohibit their use in the manner described by the source.
- ISG has not been able to determine the involvement of other sites reported by the chemical engineer to have been linked to the mobile program largely due to post-OIF events at the sites, such as turnover of personnel and looting.
- While ISG established that the chemical engineer had access to both Iraq's seed purification project and BW program, there are concerns regarding his employment and whereabouts after 1995, which is the period that he claimed to have been involved in the mobile BW program.

Origins of Iraq's Mobile BW Program

Many of the key personnel that ISG investigated were employed at the Chemical Engineering and Design Center (CEDC), which later became part of the Sa'ad Center. By the very nature of their employment, these individuals were involved in both the design and construction of the single cell protein lines at Al

Figure 1. *Reported production sites.*

Hakam—which could have been used for BW agent production—and the design and construction of legitimate seed purification plants. Background on these two programs:

- ***BW Program.*** Prior to the 1991 Gulf war, Iraq possessed a BW program that had researched, developed, produced, and weaponized agents. After the war, Baghdad effectively hid its offensive BW program from UNSCOM inspectors for nearly 5 years. Iraq claimed to have destroyed its BW agents and weapons completely in 1991, but UNSCOM was unable to verify this claim. By the departure of UNSCOM inspectors in 1998, Iraq's declared BW production capability in known fixed facilities had been dismantled.

- ***Seed Purification Project.*** Iraq's mobile BW program reportedly began amid the UN inspection process and operated under the cover of the seed purification project facilities. ISG investigations show that the seed project began in 1994 on orders of Husayn Kamil as part of Iraq's effort to improve and modernize its agricultural sector, and involved the creation of a total of ten legitimate, although inefficient and low quality, agricultural seed sorting and fungicide treatment systems that were designed to have a greater capacity and less of a health risk than seed purification plants available to Iraq at the time. The seed purification units were designed, fabricated, and installed by the CEDC. The designers considered producing a mobile system but decided on fixed plants installed in buildings. The final plant design was based on the reverse engineering of a German-manufactured seed purification plant in Tikrit. The seed purification project occurred in two phases, concluding in 1997 when all ten plants were transferred to the Mesopotamia State Company for Seeds, also known as the Al Nahrayn Company.

Denials of the Existence of Mobile BW

ISG identified nearly ninety individuals that could have been involved or were linked to sites or the source that became part of the investigation. Of these individuals, ISG located and debriefed over sixty. While many have corroborated some of the reporting on personnel and of the Sa'd Center and some legitimate activities the source claimed were cover activities, none have provided evidence to substanti-

ate the claim of a mobile BW program. The levels of cooperation from these individuals vary considerably, ranging from active cooperation to denials and evasiveness:

- Most of the individuals identified as being involved in the mobile BW program were associated with the CEDC and responsible for both the seed purification project and the single cell protein project that was the cover for the Al Hakam BW facility. ISG spoke to nearly all of these individuals and, while they have acknowledged their involvement in both of the projects, they have consistently denied the existence of a mobile BW program.

- Several key Iraqi engineers were debriefed. Each engineer denied both the creation of a mobile fermentation project and that the seed purification sites were used as legitimate cover for mobile BW agent production units. ISG officers found some of those interviewed to be less than forthcoming, but were unable to judge if the interviewees were withholding information on the alleged mobile BW project or some other project they did not want to reveal. Debriefings of High Value Detainees (HVDs) have not yielded any new insights into the existence of mobile BW agent production capabilities in Iraq.

- Personnel from Al Nasr Al Azim State Establishment, a company that produced fermentors, heat exchangers, and vessels for Al Hakam, have denied that they produced components for any mobile BW systems during the 1990s.

- Personnel from the Al Nahrayn Company denied that three of its sites housed mobile BW agent production units. ISG officers assess that the Al Nahrayn Company has usually been forthcoming and accommodating to requests for information and site visits.The current occupants of the As Suwayrah Store, Tikrit Industrial Facility, and Mosul Rail Station also deny that the facilities were utilized for transportable activities, as reported by the source. However, in the case of Tikrit, although the construction company that runs the site occupied the facility when the production units were allegedly present, current site personnel were hired after OIF and do not have historical knowledge of the facility.

Exploitation of Mobile BW Agent Production Sites

Since stand-up, ISG has exploited many sites in Iraq identified to have a connection to the mobile BW program, including the five reported production sites that remained intact after the war (Figure 2). Discrepancies remain between past descriptions of sites and physical features at the sites as found by ISG. Investigations of six additional sites have not uncovered links to the mobile BW program, which may be partially due to post-OIF activities, such as turnover of employees and looting of facilities.

Djerf-al-Nadaf Seed Purification Facility, Reported Mobile Site. ISG teams visited this site six times to examine its physical features and debrief site personnel. The teams determined that the facility is in fact operated by the Al Nahrayn Company and it's involved in seed purification. A high-bay building adjoining the primary warehouse of interest was built in 1994 and contains a legitimate two-story high seed purification unit. However, ISG also discovered differences between physical features present at the facility and those reported pre-OIF.

- ISG officers were unable to locate any evidence of reported vehicle entrances on the ends of the building that was said to have housed the BW production unit. In the course of inspections, ISG found that the building is constructed of continuous sheet metal; there were no indications that the metal on the ends of the building was altered to accommodate and then conceal the past existence of doors. The current site manager, who is a longtime employee at the site, and an engineer involved in the seed purification project, denied the past existence of the doors on the ends of the building.

- Two two-meter-high block walls around three sides of the building prevent vehicle access into the building through these reported vehicle entrances (Figure 3). ISG determined that the walls were constructed by 1997, which is when the BW production unit was reportedly on site.

- Reportedly a small building on-site was the location of the power supply for the mobile production units. An ISG examination of the reported power supply building revealed that the building consists

of two small rooms, which site personnel explained were constructed for security personnel and technicians. These individuals said that the power supply for the site came from the local power grid. However, an external generator for electricity to certain places at the site cannot be ruled out.

ISG has determined that the primary warehouse has undergone some modifications since the date of information concerning a transportable BW connection to the facility. This indicates that the building was altered, thereby raising the possibility that other less detectable modifications have occurred:

- A one-meter high concrete wall was discovered around the internal perimeter of the building. Site personnel report that the wall was built in 1999 to prevent seeds from pressing against the sheet metal walls.

A tile floor was found in one corner of the building, indicating that a room had been present and removed. Site personnel indicate that an office was present in this location, but was removed in 1999 to accommodate the need for greater space required for the seed purification activities.

Al Ahrar Seed Purification Facility, Reported Mobile Site. ISG exploited the Al Ahrar seed purification facility, the primary candidate for the site in the An Numaniyah area that reportedly housed a mobile BW agent production unit. Exploitation revealed that, although it is operated by the Al Nahrayn Company and is part of the seed purification project, it most likely did not house mobile production units.

- The facility contains four adjoining warehouses, each large enough to accommodate semi trailers; however, it was determined that the doorways of the warehouses, assessed to have housed production units, are too short to accommodate tractor-trailers the size of the described mobile fermentation units (Figure 4). There were no signs that the doorways had been altered. In addition, site personnel deny the past presence of trailers with fermentation-like equipment. They stated that CEDC employees, including individuals allegedly involved in the mobile BW program had been to the site as part of the seed purification project. A high-bay building adjacent to the warehouses contains two legitimate seed processing units that are similar to the one unit located at the Djerf-al-Nadaf facility.

Investigations of the four remaining reported production sites have yielded no evidence of their involvement in the mobile BW program:

- ***Tikrit Industrial Facility Northwest, Reported Mobile Site.*** This site was a reported location of two transportable BW plants using the cover of seed purification. ISG exploitation of the site revealed that the warehouse, which is currently used as a storehouse for a construction company, was large enough to accommodate tractor trailers (Figure 5). However, ISG found no evidence to suggest that the building is or was equipped with false walls for concealment of any such units. In addition, the site personnel explained that the facility had been a plastics factory from the 1980s until the construction company took over the grounds. Although they had no first-hand historical knowledge of the site, the site personnel stated that the facility had no connection to seed purification and had not been used as a hide site for tractor trailers.

- ***Plant Protection Division As Suwayrah Stores, Reported Mobile Site.*** The As Suwayrah Stores was identified as the most probable candidate for the site in the Al ‘Aziziyah-Sarabadi area. ISG exploitation of the site determined that the facility is a pesticide storage site with no association with the seed purification project. Measurements of the suspect warehouses indicate that the facility is large enough to conceal a mobile BW agent production unit; however, ISG has not been able to confirm if such a unit had been present in the past. Site personnel, who had been hired after OIF, had no historical knowledge of the activities at the facility; however Plant Protection Division Management with historical knowledge of the site deny that the facility was used to hide vehicles or production equipment.

- ***Mosul Rail Yards, Reported Mobile Site.*** The locomotive repair station at the Mosul rail yards reportedly was the location of the single rail-mounted BW agent production unit. While this site is not directly involved in the seed purification project, the current Director General of the Al Nahrayn Seed Company stated that the company was ordered to conceal seed purification equipment in the rail station during the 1998 Desert Fox campaign. An ISG inspection of the facility revealed that it is capable

of accommodating rail cars. However, long-time employees at the rail yard stated that the repair station had never been used to conceal unusual equipment, railcars, or trucks.

- ***Huwayjah Agricultural Facility, Reported Mobile Site.*** This site, which reportedly housed a BW production unit in the late 1990s, was completely destroyed by looters between 10 May and 26 November 2003. Al Nahrayn officials confirmed that their site in Huwayjah had been destroyed by looters and deny the past presence of mobile platforms for BW agent production. They stated that, while this site was an agricultural processing facility, it had no connection to the seed purification project.

ISG exploited three additional sites, but were unable to ascertain their link to the mobile BW program due to post-OIF activities, such as turnover of site personnel and looting:

- ***Al Mishraq Sulfur Facility, Possible Reported Dispersal Site.*** ISG assesses that the Al Mishraq Sulfur Facility could have been a dispersal site for the rail mounted BW production unit housed in Mosul. ISG exploitation of this site revealed no evidence of the unit, and site personnel claimed that they had never seen rail cars with fermentation-like equipment in them.

- ***Habbaniyah Barracks, Reported Dispersal Site.*** Reportedly, containers of BW material from the mobile units were concealed from UN inspectors by burial at the Habbaniyah Barracks. ISG exploited the site to find evidence to support this claim; however, looters had removed, among other things, a fence that reportedly would have provided a marking to assist in locating the burial site.

- ***Baghdad Unidentified Facility 'Ali Ad Dayyan.*** This site, also known as Buetha, is along the Tigris just south of Baghdad and was reported to have been associated with the BW program personnel. ISG exploited the site and determined that it had been an orange grove and chicken farm at one time but could not confirm an association with the mobile BW program. However, locals stated that it had belonged to the Iraqi Government until 1998.

Other Leads

In addition to information now judged unreliable from a key source, ISG also has sought to vet the reporting by other sources who indicated before OIF that Iraq had a mobile capability. ISG has not been able to corroborate this reporting, and these individuals are believed to be now outside of Iraq. Since it began its investigation, ISG also received information on a possible BW mobile capability from two other sources separate from those mentioned by the pre-OIF sources, but neither lead has confirmed the existence of a mobile BW agent production capability:

- Nu'man 'Ali Muhammad Al Tikriti, director of the M16 section of the IIS, made a reference to the MIC in 2000 having at least one transportable facility for work on either biological or chemical warfare agents, according to a former IIS officer. Nu'man denies knowledge of any attempts by Iraq to manufacture or use mobile facilities for a BW or CW program.

- A former senior officer in the Iraqi Army told us that he heard from his nephew, who was involved in making weapons, that Iraq had "portable biological factories or laboratories" making BW agents in 1998. Debriefings of the nephew have determined that he had hearsay information regarding movement of prohibited BW-related equipment to evade UNSCOM inspections. He claimed to have had no knowledge of a mobile BW agent production capability.

Individuals Debriefed

ISG has debriefed key individuals and visited key sites regarding the planning, design, manufacture, and operation of the reported transportable BW agent production plants.

Some of these individuals were key players directly involved with running the BW program, whereas others were either heads or associated with specific areas of the BW program. ISG interviewed

key figures, such as the suspected head of the BW program, the former Deputy Minister of Agriculture, the National Monitoring Directorate representative to the Ministry of Industrialization and Minerals, the director of the MIC, the former Minister of Industrialization and Minerals, the Minister of Transportation and Communication that had involvement in the BW program, and other important individuals that had suspected involvement with Iraq's BW program.

In the area of mobile production equipment and facilities, there were a number of key individuals interviewed. Some of these individuals included the Director of IIS Directorate of Criminology M16 that reportedly discussed mobile platforms in 2000, the director of a possible dispersal site for rail mobile units, managers of a reported mobile BW agent production site, and a former military officer who allegedly knew that Iraq had "portable biological factories or laboratories" making BW agents in 1998.

Annex D
Trailers Suspected of Being Mobile BW Agent Production Units

ISG assesses the capability of two mobile trailers with tanks or suspected fermentors on board that were recovered near Irbil and Mosul in 2003. ISG judged the mobile units were impractical for biological agent production and almost certainly designed and built for the generation of hydrogen.

Background

Iraq's Consideration of Mobile BW Agent Production Systems. Several events underpin the continuing suspicion that Iraq possessed mobile facilities and laboratories.

- In the 1980s, the Technical Research Center (TRC) at Al Salman purchased a mobile laboratory for forensic purposes in support of a proposed meeting of the Arab League or Arab Games in Baghdad. The meeting did not take place in Iraq, but Al Salman retained the laboratory.

- Later, in 1987 Dr. Rihab, head of the BW bacteriological group, and Dr. 'Amir Hamudi Hasan Al Sa'adi, MIC First Deputy and right hand man of Husayn Kamil, discussed the possibility of developing a transportable system for the production of BW agents. The idea was largely Al Sa'adi's; Rihab rejected the proposal in favor of the more pedestrian route that, in time, led to the construction of Al Hakam, Iraq's major BW research, development, testing, production, and storage facility (see Figure 1).

Discovery and Initial Exploitation of Suspect Trailer-Borne Equipment

It was against this background that Coalition Forces discovered two trailers in Northern Iraq in April and May 2003. In April 2003, a trailer (trailer 1) was recovered after its discovery in Irbil. This trailer appeared to be complete with all equipment fitted. A second, similar trailer (trailer 2) was later identified and recovered in May 2003 from a site adjacent to the Al Kindi research facility at Mosul. Some items of equipment were missing from this trailer bed.

Initial Assessments and Sample Analysis. A team of military experts conducted a preliminary technical field investigation of trailer 1 soon after its capture. They assessed the trailer to be part of a possible Iraqi mobile BW weapon production system, with its equipment being capable of supporting a limited biological batch production process. A second examination was undertaken by a team of scientific experts, after Al Kindi personnel suggested the trailers were for hydrogen production. Their report concluded, "The trailers have equipment and components possibly compatible with biological agent production and/or chemical processes that might include hydrogen production."

ISG Assessment of the Trailers

In response to questions raised by these earlier reports, a team, comprised of specialists in fermentation technology and bio-manufacturing, conducted a comparative assessment of the trailers with respect to the two major uses postulated:

- A clandestine mobile BW agent production platform.

- Field units for hydrogen production.

This assessment focuses on Trailer 1 because it appeared to have a complete set of equipment. The 'reactor vessel' was considered to be the key component of the system for evaluation because to determine its purpose as either a bio-fermentor or a chemical reaction vessel for hydrogen generation, would resolve the debate over the function of the whole assembly of equipment mounted on Trailer 1.

The Trailers as a Clandestine BW Agent Production Platform

The crucial item of equipment for the production of BW agents is the fermentor. This provides and maintains an aseptic and controlled, optimal environment for growth of the selected microorganism. A fermentor, regardless of the particular microorganism being produced, be it BW agent or not, must possess certain essential design features in order to achieve these cri-

Figure 1. *Recovered trailers allegedly for hydrogen production.*

teria. The most critical of these is the 'sterile integrity' of the fermentor and its associated pipework, in order to maintain a monoculture and prevent the ingress of 'foreign' microorganisms that might outgrow and displace the required agent.

ISG has found no evidence to support the view that the equipment had a clandestine role in the production of BW agents; and ISG judges the equipment's configuration makes its use as a fermentor impractical for the following reasons:

- There is a critical absence of instrumentation for process monitoring and control of the process.
- The positioning of the inlets and outlets on the reactor make even the most basic functions (such as filling completely, emptying completely, and purging completely the vessel) either impractical or impossible to perform.
- The lack of the ports required to introduce reagents exacerbates this problem. These aspects of the design alone would render fermentation almost impossible to control.
- The low-pressure air storage system capacity is inadequate to provide the volume of compressed air required to operate the fermentation process over a complete aerobic production cycle. In addition, it is not practical to charge and use the existing compressed gas storage with nitrogen or carbon dioxide for anaerobic fermentation. Similarly, the collection system for effluent gas would be wholly inadequate to deal with the volume of effluent gas produced during a complete production cycle.
- Harvesting any product would be difficult and dangerous.

Fermentor Design Feature	Critical Requirement Yes/No	Present on Trailer Vessel Yes/No	Required Reconfiguration Major/Minor
System sterilization	Yes	No	Major
Media/water sterilization	Yes	No	Major
Aseptic growth conditions	Yes	No	Major
Agitator/stirrer	Yes	No	Major
Aeration sparger	Yes	No	Minor
Process control instrumentation & sensors	Yes	No	Major
Addition and sampling ports	Yes	No	Major
Sight glasses	Yes	No	Major
Provision of sterile air	Yes	No	Major
Sterile filtration of off-gas	Yes	No	Major
Provision of steam for sterilization purposes	Yes	No	Major

Table 1 illustrates the assessment of the 'reactor vessel' and associated equipment system on trailer 1 against the essential features of an effective fermentor. (***Note***: *there are additional, minor design inconsistencies, which are not included in this table*.)

- A working reactor of the size of that on the trailers could produce only around 100 liters of x10 concentrated BW agent per week, not enough to fill a single missile warhead.

- In May 2003, analysis was carried out on seven samples taken from key equipment locations on the trailer, including powder and slurry taken from the 'reactor vessel'. No evidence of BW organisms was detected. The complete absence of proteins and the minute amounts of phosphorus and sulfur present were deemed inconsistent with normal bio-production.

The Trailers as Field Units for Hydrogen Gas Production

After re-examining the equipment found on trailers in northern Iraq and reviewing previous reporting, documents, and results of chemical and biological analysis, ISG judges that the Al Kindi General Establishment at Mosul designed and built the two trailer-borne equipment systems as hydrogen generators for Republican Guard artillery units for use with radio-sonde balloons. Although the equipment is poorly constructed, it is consistent with the hydrogen generation process detailed in documents from the Al Kindi Company.

The equipment on Trailer 1, although poorly constructed, is consistent with the hydrogen generation process because:

- The reactor design and sizing, large entry port to "load" the reactor, the scoop to "load" the reactor and aluminum hydroxide found in the bottom of the reactor are all consistent with production of hydrogen. Hydrogen may be produced by reacting sodium hydroxide with aluminum powder and water. The rate of reaction, and the temperature and pressure in the reactor is controlled by the rate at which water is added. The by-product is aluminum hydroxide.

- A peristaltic pump to compress the effluent gas is necessary for handling flammable products.

- A high-capacity cooling system for the reactor is consistent with the duty associated with a strongly exothermic process, such as that used for the production of hydrogen.

- A pressure-relief valve with a vent extending above the vehicle, spark resistant lighting, and a telescopic lightning arrestor found on the completed trailer indicate precautions taken with the handling of a flammable, lighter than air gas, such as hydrogen.

Moreover, reports and other documents provided by high-ranking officials from Al Kindi, detailing milestones in the manufacture and testing of the trailers, are consistent with the reporting on their stage of construction. For example, the date of the

Iraqi letter requesting an extension of the contract due to late delivery of a 'reactor vessel' corresponds with the observed lack of construction work on Trailer 2.

- The two trailers were located in late May 2002 at the Al Kindi facility in Mosul. Reporting indicated that at least one of the trailers had arrived on the site as a bare chassis fitted with a floor/bed. Over a period of 10 months between May 2002 and March 2003, both trailers had had sufficient equipment added to be described as two *'possible transportable BW production related trailers'*.

- The location of the trailers, together with the addition and removal of structural features and equipment during their construction and testing, is consistent with information in Iraqi reports and documents.

Iraqis have stated the trailers were constructed to provide a mobile capability for hydrogen gas production. Several documents give credence to this claim.

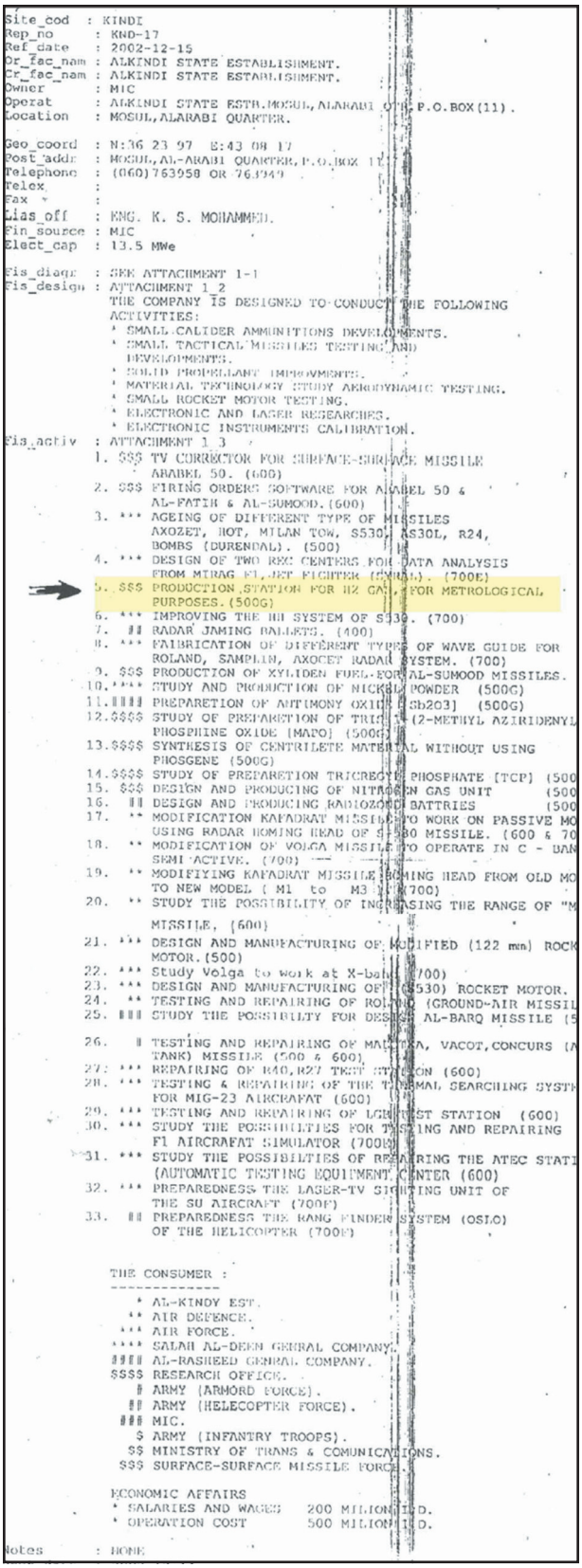
- Al Kindi in its submission for the December 2002 semi-annual declaration to UNMOVIC stated a "production station for H_2 gas (see Figure 2)."

- A letter from the Al Kindi General Company to the 'American Authority' in Mosul, explains that the trailers were manufactured as 'hydrogen field production systems' for the Republican Guard.

- Copies of the original contract and associated documents that describe the requirements, specifications and testing were provided by sources that had first hand knowledge of the manufacture and use of the trailers.

- The Al Kindi Material describes the process employed on the trailers as an attempt to improve upon one originally developed in Russia for the production of hydrogen for use in meteorological balloons.

- It is interesting to note that the Al Kindi material also includes comments (some of which are not particularly favorable) received from the Iraqi Republican Guard Artillery in relation to the suitability of the process for the job it would be required to



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Location : MOSUL,ALARABI QUARTER.

Geo_coord : N:36 23 97 E:43 08 17
Post_addr : MOSUL,AL-ARABI QUARTER,P.O.BOX 11
Telephone : (060)763958 OR 76.949
Telex :
Fax :
Lias_off : ENG. K. S. MOHAMMED.
Fin_source : MIC
Elect_cap : 13.5 MWe

Fis_diagr : SEE ATTACHMENT 1-1
Fis_design : ATTACHMENT 1_2
THE COMPANY IS DESIGNED TO CONDUCT THE FOLLOWING ACTIVITIES:
' SMALL CALIDER AMMUNITIONS DEVELOPMENTS.
' SMALL TACTICAL MISSILES TESTING AND DEVELOPMENTS.
' SOLID PROPELLANT IMPROVMENTS.
' MATERIAL TECHNOLOGY STUDY AERODYNAMIC TESTING.
' SMALL ROCKET MOTOR TESTING.
' ELECTRONIC AND LASER RESEARCHES.
' ELECTRONIC INSTRUMENTS CALIBRATION.

Fis_activ : ATTACHMENT 1_3
1. $$$ TV CORRECTOR FOR SURFACE-SURFACE MISSILE ARABEL 50. (600)
2. $$$ FIRING ORDERS SOFTWARE FOR ARABEL 50 & AL-FATIH & AL-SUMOOD.(600)
3. *** AGEING OF DIFFERENT TYPE OF MISSILES AXOZET, HOT, MILAN TOW, S530, AS30L, R24, BOMBS (DURENDAL). (500)
4. *** DESIGN OF TWO REC CENTERS FOR DATA ANALYSIS FROM MIRAG F1 JET FIGHTER (SMALL). (700E)
5. $$$ PRODUCTION STATION FOR H2 GAS FOR METROLOGICAL PURPOSES.(500G)
6. *** IMPROVING THE HH SYSTEM OF S530. (700)
7. ## RADAR JAMING BALLETS. (400)
8. *** FABRICATION OF DIFFERENT TYPES OF WAVE GUIDE FOR ROLAND, SAMPLIN, AXOCET RADAR SYSTEM. (700)
9. $$$ PRODUCTION OF XYLIDEN FUEL FOR AL-SUMOOD MISSILES.
10. **** STUDY AND PRODUCTION OF NICKEL POWDER (500G)
11. #### PREPARETION OF ANTIMONY OXIDE (Sb203) (500G)
12. $$$$ STUDY OF PREPARETION OF TRIS (2-METHYL AZIRIDENYL PHOSPHINE OXIDE (MAPO) (500G)
13. $$$$ SYNTHESIS OF CENTRILETE MATERIAL WITHOUT USING PHOSGENE (500G)
14. $$$$ STUDY OF PREPARETION TRICRECYL PHOSPHATE (TCP) (500
15. $$$ DESIGN AND PRODUCING OF NITROGEN GAS UNIT (500
16. ## DESIGN AND PRODUCING RADIOZOND BATTRIES (500
17. ** MODIFICATION KAFADRAT MISSILE TO WORK ON PASSIVE MO USING RADAR HOMING HEAD OF S-530 MISSILE. (600 & 70
18. ** MODIFICATION OF VOLGA MISSILE TO OPERATE IN C - BAN SEMI ACTIVE. (700)
19. ** MODIFYING KAFADRAT MISSILE HOMING HEAD FROM OLD MO TO NEW MODEL (M1 to M3) (700)
20. ** STUDY THE POSSIBILITY OF INCREASING THE RANGE OF "M MISSILE, (600)
21. *** DESIGN AND MANUFACTURING OF MODIFIED (122 mm) ROCK MOTOR.(500)
22. *** Study Volga to work at X-ban (700)
23. *** DESIGN AND MANUFACTURING OF (S530) ROCKET MOTOR.
24. ** TESTING AND REPAIRING OF ROLAND (GROUND-AIR MISSIL
25. ### STUDY THE POSSIBILTY FOR DESIGN AL-BARQ MISSILE (5
26. # TESTING AND REPAIRING OF MALUTKA, VACOT,CONCURS (A TANK) MISSILE (500 & 600)
27. *** REPAIRING OF R40,R27 TEST STATION (600)
28. *** TESTING & REPAIRING OF THE THERMAL SEARCHING SYSTE FOR MIG-23 AIRCRAFAT (600)
29. *** TESTING AND REPAIRING OF LGB TEST STATION (600)
30. *** STUDY THE POSSIBILTIES FOR TESTING AND REPAIRING F1 AIRCRAFAT SIMULATOR (700E)
31. *** STUDY THE POSSIBILTIES OF REPAIRING THE ATEC STATI (AUTOMATIC TESTING EQUIPMENT CENTER (600)
32. *** PREPAREDNESS THE LASER-TV SIGHTING UNIT OF THE SU AIRCRAFT (700F)
33. ## PREPAREDNESS THE RANG FINDER SYSTEM (OSLO) OF THE HELICOPTER (700F)

THE CONSUMER :
* AL-KINDY EST.
** AIR DEFENCE.
*** AIR FORCE.
**** SALAH AL-DEEN GENRAL COMPANY.
AL-RASHEED GENRAL COMPANY.
$$$$ RESEARCH OFFICE.
ARMY (ARMORD FORCE).
ARMY (HELECOPTER FORCE).
MIC.
$ ARMY (INFANTRY TROOPS).
$$ MINISTRY OF TRANS & COMUNICATIONS.
$$$ SURFACE-SURFACE MISSILE FORCE.

ECONOMIC AFFAIRS
* SALARIES AND WAGES 200 MILION I.D.
* OPERATION COST 500 MILION I.D.

Notes : NONE

Figure 2. *Document denoting alleged "hydrogen production" function.*

do. In summary, their conclusion is that the process plant/trailer combination is too bulky and that the trailer is not rugged enough for the process to be considered a truly mobile "field" system. A smaller capacity plant might be more compatible with the needs of meteorological units requiring self-sufficiency in terms of hydrogen availability.

- The level of detail provided in the Al Kindi Material makes a highly credible case for hydrogen generation. It would have been extremely difficult to fabricate data to this level of detail.

Detailed Assessment Of The Suspect Trailers Recovered From Irbil and Mosul 2003

Evaluation of the Possible Use of the Trailers as a clandestine BW Agent Production platform

Air Supply

Air is used in the process to provide aeration for the reactor, for transferring liquids as required throughout the process, and after the production cycle for purging vessels and pipework that have had contact with the inoculum, the culture broth, and/or contaminated gases. Air is drawn into a low pressure (0-40 bar) compressor set via a simple activated carbon filter F-2, compressed and fed to the integral storage reservoir (S-11) of the compressor set. Compressed air from the compressor reservoir is fed either directly to the reactor via vessel T-3 or to a bank of five 40l "K" bottles (S-1 to S-5). The air stored in this cylinder bank is available as an emergency reserve for use to shunt liquids around the process as required without having to rely on the compressor set. The air supply system may be vented via Valve V-3.

Major Components of the Trailers

The Trailers. *Both trailers had been used previously, probably as transporters for heavy construction equipment and the like. They show signs of damage and wear, such as a heavily dented and uneven truck bed. They are of different lengths. There is a tube frame with horizontal welded steel straps to support a canvas cover. The frame also supports light fittings.*

The Equipment. *The principal items of equipment mounted on the Irbil trailer are:*

- **Chiller.** *The forward portion of the trailer is almost entirely occupied by a large chiller unit, capable of pumping copious volumes of cold water through a pipe circuit to other items on the trailers. The chiller is powered by electricity.*
- **Electrical Switch Panel.** *On the side of the trailer, there is an electrical control box.*
- **Low Pressure Air Compressor.** *An electrical air compressor fed from the atmosphere through a small filter is attached to a reservoir.*
- **Bank of 5 Air Storage Cylinders.** *The pipe work from the air compressor connects with 5 fixed air bottles.*
- **Large Water Tank.** *Near the center of the trailer is a large stainless steel water tank that connects to the water pumping system. The tank is provided with a loose fitting lid. It is not sealed.*
- **2 Feed Tanks.** *After passing through a very small filter, water can be metered and pumped into two tanks.*
- **Reactor Vessel.** *To one side toward the rear of the trailer there is a reactor fabricated in stainless steel by the State Establishment for Heavy Equipments Engineering (SEHEE), Baghdad (see Figure 3 (a) and (b)).*
- **High-Pressure Compressor.** *After cooling, the gas produced by the reactor is compressed in a high-pressure compressor housed in a strong steel box.*
- **Bank of 5 Product Storage Cylinders.** *The compressed gas is fed into 5 storage bottles, held in a box that can be rotated to ground level to assist with handling of the product (see Figure 4).*

Figure 3 (a). *Trailer 1 reactor vessel.*

Figure 3 (b). *Trailer 1 data plate on reactor vessel.*

Figure 4. *Trailer 1 box for holding product 'K' bottles.*

Comment and assessment

- The simple filter F-2 is not of a design that will provide sterile compressed air to the process. A HEPA filter could be fitted to address this problem, although this would not be a minor modification.

- Large amounts of compressed air are required for each production cycle (see 2.6) and the risk of contamination (failure) of any given batch is increased if process air is not sterilized.

- The low pressure compressor set is of standard reciprocating design and will not provide "oil-free" air. Oil-free air compressors are often specified in fermentation installations though in this particular concept (i.e. the production of "fire-and-forget" BW agents), it is unlikely to be a critical factor.

- These trailers were not designed with anaerobic fermentations in mind. Although it would be possible (but extremely inconvenient) to connect nitrogen cylinders to the sparge system, it is noteworthy that no provision has been made on the trailers for the

storage of gas cylinders other than the five designated for air storage. These cylinders are permanent fixtures and cannot easily be removed/substituted with other gas cylinders containing N_2 or CO_2. ISG concludes that anaerobic fermentations (e.g. *Cl. botulinum* and *Cl. perfringens)* would not normally be conducted on the trailer.

Water Supply

Water tank T-1 provides water for dilution of medium concentrate, for wash-down, for charging the chilled water system, and for chiller system make-up. Dilution and/or wash-down water can be introduced to the process by 2 routes:

- Indirectly, via pump P-1 and valve V-8 into vessel T-2. This route could be used for providing process water for medium concentrate dilution (see 2.4) to the reactor. When full, vessel T-2 is isolated from the system (at V-8), vented (at V-9), and its contents delivered via flowmeter FM-1, cartridge filter F-1, and positive displacement pump P-2 into the reactor (T-4). [N.B. The reactor must also be vented during this process via the overpressure relief assembly bypass valve (V-15)].

- Directly (and quickly): into vessel T-3 via valve V-7 and pump P-1. This route would be used for providing water for wash-down or cleaning, and possibly as part of the postproduction purging cycle.

Comment and assessment

- The simple cartridge filter (F-1) is not of a design that will provide sterile water to the process. This filter assembly is located at very low level. The whole filter assembly would need to be repositioned and repiped if a sterile water filter is to be fitted. This is not a minor modification.

- Vessels T-2 and T3 lack any form of liquid level indication and will be difficult to use when fed by pump P-1.

Chilled Water System

The chiller system provides cooling water to the reactor, the gas-drying condenser, and the high-pressure gas compressor.

Prior to first operation, the chiller circuit must be filled with water from the water storage vessel T-1. When this has been done the system should require little by way of make-up water because it is a sealed system and little evaporation can occur. Cooled water is circulated around the system by pump P-3

Comment and assessment

- Notwithstanding the other loads on this process (H.P. compressor and effluent gas cooling), ISG believes that the cooling load presented by a relatively small fermentation operation at perhaps 30°C - 40°C (a typical temperature range for *B. anthracis*) does not justify a cooling plant of the size specified for the process as found.

- However, it would be fair to say that the output of this unit can be modulated and the fabrication shop may not have had the luxury of choice and was obliged to use equipment available at the time.

Metered Water Supply System (Vessel T-2)

The metered water supply system comprises a vented supply vessel (T-2), a flowmeter, an in-line cartridge filter (F-1), and a dosing pump (P-2) (see Figure 5).

Note that vessel T-2 can only receive water from the main water tank. It may receive other liquids through the vent valve V-9 so long as the vessel is aspirated via vessel T-3 and the air supply line vent valve V-3. The valve arrangement does not allow liquids to be received from tank T-3.

Comment and assessment

- Vessel T-2 is not equipped with any form of liquid level indication and will be difficult to operate because of this.

Figure 5. *Trailer 1 water filter.*

- The glass fiber cartridge filter F-1 will not remove all microbial contaminants from the water supply and therefore the process water treated by this means will not be sterile. In ISG's view, neither the medium concentrate nor the inoculum should be introduced to the process via valve V-9. The medium concentrate is a complex medium and may contain aggregates that will collect on and bind the in-line cartridge filter F-1. The inoculum will have been prepared under sterile conditions and it makes no sense to filter things that are already sterile.

- A large amount of process water is required for each production cycle (as dilution water and for system purge). The risk of contamination (failure) of any given batch is increased if the process water is not sterile. In this regard, it is important to ensure that the initial seed culture contains sufficient viable organisms in log phase to ensure that potential contaminant microorganisms cannot compete.

- Vessel T-2 would be ineffective if used for dilution water either. Running the water through a filter that is incapable of removing any solids smaller than fine sand particles will make little difference to the fermentation performance. Some 360-390 liters of dilution water is required for each production run. Given that the capacity of vessel T-2 is 166 liters, this vessel would need to be recharged twice during the operation. The maximum flow rate for the metering pump is only 30 liters/minute. This makes charging the reactor an unnecessarily lengthy operation.

Inoculum and concentrated culture medium vessel (T-3)

Vessel T-3 is piped up to receive process water (see 2.2). It may also act as a transfer vessel for the inoculum and the growth medium (possibly as a concentrate) via valve V-12. If used in this way, vessel T-3 must first be aspirated through valve V-3 on the air line. The inoculum and the growth medium would be transported to the trailer in pressurizable containers with suitable fittings such that the contents could be "blown" into T-3 by using either a foot pump or from the onboard air storage via a flexible hose.

During the production cycle, vessel T-3 needs to be empty because all process air required by the reactor has to be passed through it.

Comment and assessment

- The purpose of vessel T-3 is not entirely clear. It is a totally closed, unlagged tank having neither a dedicated vent nor a liquid level indicator. A difficult vessel to use.

- The only ways to vent this vessel are via valve V-3 on the air supply line or through the reactor and out via the over-pressure bypass valve V-15. Neither method would be available during the production cycle because the air supply system will already be in use.

- As piped up, liquid contained in vessel T-3 cannot be passed to vessel T-2. This means that neither the medium concentrate nor the inoculum can be metered into the reactor. Also, it means that the only entry point by which concentrated medium and/or inoculum can gain access to the process is via vessel T-3.

- Steam and/or hot water required (provided from a stand-alone utilities vehicle) would be admitted to the process via valve V-12.

- There is no convenient coupling present at valve V-3 for attaching temporary hoses for passing steam, inoculum, or concentrated growth medium into vessel T-3.

- During the production cycle, vessel T-3 must be empty because process aeration is required.

- It is assumed that the air feed pipe does not extend into vessel T-3 because, if it did, the vessel would be impossible to fill.

Reactor

The reactor (vessel T-4) is a vessel fabricated in 30mm 316 stainless steel and is of an unusual design for the cultivation of microorganisms in that its principle features are:

- A flat base and a hemispherical top

- With the exception of what would be the air sparge inlet and the drain point, all other connections and the access way are side mounted

- The vessel jacket (3mm 316 stainless steel) completely covers the top of the reactor within but the base of the vessel is not cooled.

- There is no means of assessing liquid level in the vessel.

The vessel is provided with an air supply, an overpressure safety relief valve plus manual bypass, a drain point, an effluent gas outlet, a temperature gauge, 2 pressure gauges, and a spare unused instrument stub. The vessel jacket is provided with two chilled water inputs, one cooling water return port, a temperature gauge, and a pressure gauge.

If the process were to be used as a mobile BW agent production unit, vessel T-4 would be used for the production of the BW agent. The inoculum (prepared elsewhere and delivered to the Trailer), the growth medium (prepared elsewhere and delivered to the Trailer probably would be supplied as a concentrate) and dilution water are fed into the vessel. Stirring and aeration of the culture is achieved by injecting low pressure compressed air into the reactor (presumably through a sparge ring). Used air could escape from the reactor through the effluent gas outlet connection.

Comment and assessment

- ***Reactor capacity.*** The dimensions of both reactors (the Mosul Trailer and the Irbil Trailer) were taken, and these measurements are represented on a diagram in the appendix. The reactors are, for all intents and purposes, of the same capacity. The internal height of the reactor is 1873mm and its nominal capacity is 864.5l. Bearing in mind that the placement of the reactor connections limits the extent to which the reactor can be filled in practice, the total usable capacity of the vessel (i.e. to the level of the effluent gas outlet) as 633l. All fermentations are prone to foaming. A sight-glass permits operators to monitor the foaming and hence control it by adding reagent or adjusting other parameters. This design has no sight-glass. Under no circumstances should any liquid be allowed to enter the gas recovery system as this would, after a short time cause the catastrophic failure of the high pressure compressor. This imposes a limitation of the maximum volume at which the reactor can be operated. ISG would expect the working volume of this vessel to be in the region of 450l (approximately 70% of the total usable volume of the reactor) (see Figure 6).

- ***Aeration & stirring.*** The air supply pipe penetrates the vessel only to a depth of approximately 973mm leaving a distance of 900mm between the end of the air supply pipe and the base of the reactor. The sparge tube must extend to the base of the reactor if any aeration and stirring is to be achieved, but no sparge assembly or even a flexible hose of suitable diameter has been found. In one Trailer (Mosul - the less complete of the two), the air supply pipe is threaded presumably to receive an air sparge ring attachment whereas in the other Irbil Trailer the air supply pipe has no thread or other fitting. That there should be a difference between the sparge tubes is somewhat puzzling. The most efficient way to achieve maximum oxygen transfer rate is to use an impeller (mechanical stirrer) under turbulent flow conditions. Direct air injection alone will provide some mixing of the reactor contents but is not an efficient method of transferring oxygen into the culture medium. The consequence of this is that this reactor will require much more air than would be necessary under the impeller option (see Effluent Gas Collection).

Figure 6. *The inside of the reactor vessel on trailer 2.*

- ***Vessel venting.*** The vent valve of the reactor is not fitted at the top of the vessel as would normally be expected but rather at the side 1,260 mm above the base of the reactor. This distance corresponds to the highest venting points of the reactor (the emergency pressure relief outlet and the effluent gas offtake). This means that the reactor cannot be filled to capacity (e.g. for cleaning). As noted in above, the total useable volume of the reactor is 633 liters and the useable working volume will be 450 liters.

- ***Antifoam addition.*** There is no antifoam addition point on the reactor and no sight-glass by which to gauge whether or not antifoam addition is required. Although antifoam may be incorporated in the culture medium as a standard component medium prior to its introduction to the reactor, it is unusual to find that the production cycle can be completed without the addition of further amounts of antifoam. The construction of the reactor indicates that this process will be conducted at pressures up to 10 bar gauge; under such conditions the culture would be particularly prone to foaming at certain times during a normal production cycle (e.g. at start-up of the effluent gas collection compressor and at sample collection).

- ***Process monitoring and control.*** The reactor vessel is not provided with any probe port(s), or a sampling port. An assessment in a previous report postulates that the operators of the plant would run the process according to a standard operating procedure and would require no knowledge of the agent being produced. pH change is normally monitored during the production cycle. Culture mediums are usually buffered to cushion the effect of microbial activity as the production cycle progresses but, more often than not, the addition of acid or alkali is usually required at some point during the cycle. An addition port would be required on the reactor for this purpose. Dissolved oxygen concentration is also an important parameter (particularly in cases where the aeration system is not efficient. A probe location point is required for this. ISG maintains that without these monitoring and control items, any fermentation would be almost impossible to control.

- The level of instrumentation provided is insufficient for the purpose of producing BW agents on a routine basis. Without sight glasses or level indicators it is impossible to assess liquid levels in any of the vessels. Furthermore, the process would need to be pressurized (layout and disposition of vessels will not permit gravity flow from one place to another) and as such would be very hazardous to operate when producing highly toxic BW agents. Technical operators would have to be aware of the nature of the work they were conducting.

- ***Reactor harvest and cleaning.*** Reactor discharge takes place via drain valve V-14 into a length of ½" (inner diameter) pipe extending over the edge of the trailer (see Figure 7). It would be normal to see some form of coupling or flange on the discharge pipe but the end is not even threaded. As it stands, the only way to transfer the reactor contents would be to push a flexible hose over the discharge pipe outlet. The reactor contents would have to be "blown" by compressed air to a container or equipment of some kind, either on the ground or on another vehicle—making it an unnecessarily risky operation. There are no suitable receptacles on the trailer. The drain valve is sited some 2cm above the floor of the vessel. This means that the reactor can

Figure 7. *Outlet valve and pipe on the reactor vessel of trailer 1.*

Figure 8. *Solids in the bottom of the reactor vessel on trailer 1.*

never be completely emptied. To carry over some of the culture to the next production cycle will not cause any problem (apart from a reduction in productivity) so long as the culture remains sterile. Where it is critical is in the event of a contaminated or failed batch. Removing by hand the highly toxic remnants of the failed batch from the reactor would be no easy task. At Al Hakam, Iraq's principal BW facility, the production run failure rate was reported as running at 10 to 20 per cent. The production conditions were far better than they would be on these trailers, so ISG would anticipate high failure rates using this process as a mobile BW agent production platform.

- Sampling. No dedicated sample port is provided. The only means of sampling mid-cycle would be from the drain valve located at the base of the reactor. The dispositions of the drain valve and the outflow of the discharge pipe are such that two operatives would be required to perform the sampling operation (see Figure 8).

Productivity Issues

With a working volume of only some 450l, this reactor could hardly be described as a production scale unit. Each cycle will be approximately 48 hours in duration (a culture time of 36 hours plus 12 hours turnaround) and would be expected to yield only some 45 liters of 10x concentrated BW agent. On this basis, 2 production cycles (at least 4 days' production) would be required to produce sufficient BW agent to charge a single R-400 bomb (Fill capacity of 90l).

Effluent Gas Handling

Effluent gases from the reactor exit the vessel and are cooled by passage through the condenser/cooler X-2. Condensate is collected in the knock-out pot T-5 and the dried gases are passed to a high pressure compressor via a particulates filter F-3. The gases are

compressed to approximately 100 bar and passed to a storage bank comprising five 40l "K" bottles (S-6—S-10) such that the process as a whole presents a zero effluent signature (i.e. all air input during complete cycle, less an amount of oxygen removed for respiration, but plus, the carbon dioxide respiration product). Some personnel who have exploited the equipment maintain that if this system was to produce BW agent then the effluent gases would be collected in order to reduce the risk of detection.

Comment and assessment

The notion of collecting and storing effluent gases from this process is a completely impractical and unnecessary proposition and is discounted. ISG found no testimony or evidence, physical, documentary or circumstantial, to support any such procedure.

- Air requirements. Conducted at ambient pressure, a mechanically stirred reactor will normally require an air flow of 0.5 x the reactor working volume per minute at the start of the process cycle. The air rate will increase to around 1.0 volume per minute as the cell density increases. In this case, the reactor working volume is 450 liters and if a 36-hour fermentation run is assumed at an average air flow rate of 0.75 reactor working volume per minute, the total air consumed for the complete cycle will be 450 x 0.75 x 36 x 60l = 729,000l ($36m^3$/hr). Note that this estimate is conservative because it assumes air rates characteristic of mechanically stirred vessels. The reactor on the trailer has no stirrer.

- Storage capacity. In contrast to this, the 5 x 40l "K" Bottles, each pressurized to 100 Bar, would hold the equivalent of a combined storage ability of (5 x 40) x 100 = 20,000l of air from the reactor if at atmospheric pressure. When set against the 729,000l of effluent gases produced during a single production cycle, the effluent gas storage system capacity falls far short of the duty required.

- It is unknown what would happen to "K" bottles once pressurized. The operators would still have to take them away for discharge.

Evaluation of Other Possible Uses of the Trailers

Although a number of uses have been proposed for the trailers, ISG found no evidence to support those uses. It is the view of the ISG that none is feasible.

- A number of potential uses have been suggested for the trailers:

  –Possible Reverse Osmosis Water Purification Unit (ROWPU)

  –Possible Chlorinization *[sic]* Plant

  –Possible Chiller Plant

  –Possible Desalinization *[sic]* Plant

  –Possible CW Production (least likely)

Although the chiller unit could obviously be used on a stand-alone basis, there is no evidence to support any of the remainder, thus they are discounted.

Evaluation of the Technical Detail in Documents Pertaining to the Trailers Recovered From the Al Kindi General Establishment

Process Outline

The process is a hydrogen generator. For the production of $1m^3$ of hydrogen, the Russian equipment required 1Kg Al powder, 100g of NaOH (solid crushed), and 6l of water. The reactor size was 60l. Rudimentary means of cooling of reactor contents and product H_2 was provided. The Iraqis identified the following problems with the Russian system:

- Thermal runaway of the reactor (lack of effective cooling and temperature readouts).

- Lack of control of gas flow during hydrogen generation because of the use of flexible hoses and lack of pressure regulation systems (operator hazard judged "high").

- Process was skid mounted and was heavy and difficult to handle.

- Russian version of the process was suitable only for filling balloons directly, there being no gas storage capability.

- There was no pressure relief valve (PRV) on the reactor.

The Iraqis set about designing and building an improved version of the Russian equipment in order to overcome the above limitations. Specifications of the major equipment items are listed.

Major Equipment Items
Main Reactor
Produced by Al Nasr Al Azim Company in stainless steel 316; pressure tested to 16 Bar gauge; wall thickness 30mm; reactor internal diameter 800mm; height 1,150mm; manway access diameter 400mm; 2 x pressure gauges; 1 x temp gauge; 1 x safety valve; gas draw-off pipe diameter ½ " stainless steel; reactor jacket fabricated in stainless steel 304 thickness 3mm; annular depth 100mm; height 1250mm; cooling water inlet/outlet diameter 2"; 1 x temp gauge; 1 x pressure gauge; reactor gas draw-off pipe contained within cooled water jacket extension; complete assembly mounted on 1,500 x 1,500 s/s316 baseplate with height of 30 mm.

High Pressure Air Compressor
Diaphragm type with capacity of 4-10 ft^3/min at 400 Bar. Fed by gas from the reactor after having passed through a condenser stage to remove water vapor and a particle filter. After compression, the gas is fed to filling pipes via a pressure regulator valve.

Water addition system (to reactor)
High pressure pump at 30 Bar is used for this purpose. Water can be drawn from either the main tank (working volume 2,500 liters) or from the secondary tank (working volume 100 liters). All water passing to the main reactor is measured by an in-line water meter.

Air Bottle Storage System (20 Bar)
5 x K Bottles provided to supply air. This system is connected to the secondary tank (working capacity 100 liters).

Chilled Water System
Twin cooler/4 x Fan assembly. Output 35 cooling tons with an outlet temperature of 5°C-10°C. Motor rated at 35 HP DWM Kaplan. Circulation pump capacity is 40m^3/hr.

Motor Control Center
Contains all switches, starters, relays, and ancillary equipment necessary for the operation, monitoring, and control of the process.

Trailer
The entire plant is mounted on a trailer (12m x 3m) and 4m high (see Figures 9 and 10).

Process Description
This is a batch process designed to produce sufficient H_2 to fill 5 x 40l "K" Bottles to a pressure of between 45-50 Bar. This requires 10-12kg of Aluminum powder (200-300 micron), 1-1.5kg flaked/granulated NaOH, and 25-30 liters of water.

Aluminum powder is distributed in an even layer over the base of the reactor and the NaOH layered over it. The reactor is sealed and water is added according to the following schedule:

- 5 liters (monitoring increase in pressure to between 1-2 Bar).

- 5 liters (monitoring pressure rise to between 3-3.5 Bar).

- 5 liters (monitor pressure to 4 Bar). Start draw-off and compress the gas to the storage cylinders for 3 hours.

- Add the final 10 liters of water and continue drawing off the gas evolved until a cylinder pressure of 45-50 Bar is reached. Reactor temperature should not be allowed to exceed 50°C during the above procedure—cooling water is normally only used in the summer months because it slows down the reaction.

The Opinions of the High-Value Detainees (HVD)

Shortly after the discovery of the trailers, five HVDs and one senior Iraqi scientist were shown the equipment and their opinions were noted. The six individuals all had intimate involvement with Iraq's BW program, or its concealment. All denied having seen the trailers previously or knowing anything about them. They were puzzled and offered a wide range of opinions. Those who were asked dismissed the suggestion that they were for the production of hydrogen.

- *Dr. Rihab Rashid Taha Al Azzawi, head of the bacteriological BW program, was quite sure it was not a BW laboratory because of the absence of a steam generator, appropriate filters, essential instrumentation, and ports for adding reagents.*

- *Prof. Nasr Husayn Al Hindawi, who was an advisor to Dr. Rihab and not a detainee, was "95%, or maybe a little less" sure that they were for biological use. Prof Hindawi had also been shown photographs of the equipment.*

- *Dr. Mahmud Farraj Bilal Al Samarra'i, responsible for weaponization aspects of the BW program, said they were not for CW agents; he was "85% sure" they were for BW, later he dropped this to 80%.*

- *Dr. 'Amir Hamudi Hasan al Sa'adi, a chemical engineer and Senior Deputy at MIC to Husayn Kamil, explained "Anyone who told you this is bio should be fired." He pointed out that it was also unsuitable for CW agent production. Later he put forward a theory that they were designed to produce enhanced fuel for SA-2 missiles as part of the Iraqi Air Defence effort. He claimed the energetic fuel would increase the range of the weapon system.*

- *Minister 'Abd-al-Tawab 'Abdallah Al Mullah Huwaysh, former Minister of Military Industrialization and head of MIC, was sure that it was not biological; he thought it was a chemical process, but not military, although it might be for producing a payload for a UAV.*

- *Husam Muhammad Amin Al Yasin, Head of the National Monitoring Directorate and a missile expert, did not express an opinion about use, but stated that the vessels should have been declared to the UN, and if this had not been done it was a clear violation.*

The high-pressure compressor is set to provide compressed hydrogen at 45 Bar to the 5 "K" Bottles. On completion of filling, the filler regulator valve is closed and the compressor switched off. The reactor and process pipework are depressurized and the whole system vented to air.

After every 2 or 3 runs, the residue (a mixture of $NaOH/Al(OH)_3/Al$) remaining at the bottom of the reactor is removed and discarded.

Process Trials

On 29 December 2002, the process was trialed at the Al Kindi Company in the presence of representative from the Republican Guard Artillery Trials and Acceptance Section. 5 cylinders were filled to a pressure of 50 Bar. The hydrogen was used to inflate and deploy a meteorological balloon (volume 2.5-3.3m^3) loaded with radio and radar deflection equipment. The process was signed off and handed over on 11/3/2003.

Cost

250 million Iraqi Dinars for each trailer.

Notes on the Process

[Several points were noted by the Republican Guard in connection with the suitability of the process for its stated use.]

- The process is not considered a true "field" system because it is not rugged enough and is both large and heavy.

- The gauges require external protection (operator safety).

- All pressure and temperature gauge connector stubs need to be shortened, protected, and insulated.

- A smaller capacity plant might be more compatible with the needs of the Met Sections of those forces that need to be self-sufficient in hydrogen.

- The target purity for the hydrogen product is 99.9% if the performance characteristics of the balloons are to be achieved. This purity cannot be guaranteed and therefore balloon performance is compromised,

- Clear operating instructions to be displayed on the trailer,
- Trailer needs to be lightly armored (shrapnel proof),
- 2 x powder fire extinguishers are required (6kg total),
- It would be possible to make a smaller version (enhanced mobility)—if the various pieces of equipment needed could be procured.

Evaluation of the Documents Pertaining to the Trailers Recovered from the Al Kindi General Establishment

Summary

Al Kindi and the Republican Guard Command signed a contract on 23 June 2001 under which Al Kindi would produce two hydrogen generating units for what was described as weather air stations for 50,000,000 Iraqi Dinars. Work was scheduled to last 16 months from 1 July 2001 to 1 November 2002. Work went more slowly than planned. Al Kindi blamed the State Enterprise for Heavy Equipments Engineering (SEHEE) in Baghdad, the sub-contractor that fabricated the reactor vessels. There were discussions concerning the provision of towing vehicles, an item missing from the original contract. Al Kindi failed to achieve the contract completion date in November 2002, and informed the Republican Guard of a six-month delay. In December 2002, in its semi-annual declaration to the UN, Al Kindi listed the 'production station for H2 gas' along with many other projects then on hand. The first of the two trailer-borne units was completed in early 2003. A joint Al Kindi and Republican Guard group tested the system on 11 March 2003. They concluded that, although the equipment produced hydrogen according to the specifications, there were many unsatisfactory features. Despite this, in late March 2003, the Military Industrial Commission (MIC) wrote to the Republican Guard urging them to collect the completed equipment. They did not do so. Al Kindi was still assembling the second trailer when OIF started. Both trailers remained at Al Kindi at the start of OIF.

On 19 April 2003 the first trailer, with its equipment largely intact, was recovered from looters and exploited by Coalition personnel. On 11 May 2003, the second trailer was recovered from Al Kindi. It appeared to have suffered some looting. It too was exploited by Coalition personnel.

The exploitation effort included visiting Al Kindi. Managers, engineers, and scientists who had been involved in the project were debriefed. They provided copies of supporting documents. The equipment was measured, photographed, and samples taken of material within the first system.

Documents

Al Kindi provided a dozen documents and working notes. This material was translated and analyzed. For ease of understanding this material is presented as a chronology:

23 June 2001. Contract No. 73/MD/RG/2001 for the fabrication of 2 hydrogen generation units is issued at a total cost of 500,000,000 Iraqi Dinars. The specifications are listed.

July 2001. Start date of Al Kindi contract for the production of the trailers.

5 February 2002. Al Kindi letter to Republican Guard discussing use of small towing vehicle to pull trailers.

15 October 2002. Al Kindi letter to Republican Guard informing them of late running of contract.

After 15 October 2002. Undated chart labeled Technical Progress.

1 November 2002. Theoretical end date of contract—6-month extension requested.

15 December 2002. Al Kindi mentions the station for generating hydrogen gas for a semi-annual declaration to UNMOVIC.

29 December 2002. Report issued by the Command of the Republican Guard Artillery, the Branch of Examination and Acceptance of the Republican Guard and the Working Group from Al Kindi. The report reviews what has been achieved against the provisions of the contract. All the items listed conformed to the required specification. A test produced hydrogen in the capacity required. A lightning rod was in place for safety. The observations include statements that the system is not field-worthy because it is heavy and requires a towing vehicle, and it needs for protection. Al Kindi is recommended to address the necessary changes.

8 January 2003. Unspecified RG correspondence referred to in 23 January 2003 letter.

22 January 2003. Top Secret letter from MIC to Al Kindi requesting action on observations on contract.

23 January 2003. Letter from Republican Guard to Al Kindi with observations on the trailers.

5 February 2003. MIC letter to RG Artillery Commander dated 5 February 2003. The letter discusses the procurement of a towing vehicle.

26 February 2003. Letter from Republican Guard CoS to Republican Guard Artillery Commander discussing TS correspondence of 8 January 2003 requesting an opinion on an unspecified matter in connection with the contract.

11 March 2003. The day that the equipment was tested. Shortly after a signed log of the results was produced.

23 March 2003. MIC letter to the Artillery Command of the Republican Guard, discussing the 11 March 2003 test results for contract 73/MD/RG/2001 and requesting that the vehicle be picked up as quickly as possible.

25 April 2003. On 19 April 2003, Kurdistan Democratic Party (KDP) elements confiscated a tractor and trailer near a checkpoint at Tall Kayf in northern Iraq. The trailer was stolen by a looter from a truck park in northwest Mosul near an ammunition plant. Upon investigation, it was apparent that the trailer may be part of the Iraqi transportable CBW system. US forces then moved the trailer to Irbil air base for further investigation. The gooseneck trailer has two rear axles and accommodation in the frame for a third also at the rear. A telescoping rod, which could raise roughly nine meters, was located at the rear left corner of the trailer. Roughly three to four inches of a solid light brown material beneath a one half-inch liquid layer was inside. Despite wearing protective mask, an ammonia odor was noted. The pH of the material was fourteen. A rusted hand shovel was located at the base of the reaction vessel. Color coded valves had been taped to prevent overspray during painting; masking tape had not been removed from one valve indicating that the valve had not been used since the trailer was painted.

30 April 2003. Information from a technical evaluation and intrusive examination by coalition personnel of the equipment and piping system resulted in a flow schematic consistent with batch production of biological (likely bacterial only) agents. This unit does not appear to perform any function beyond the production of biological agents.

11 May 2003. US forces found a second 'suspected mobile BW agent production' trailer outside Al Kindi Research, Development, Testing and Evaluation Center in Mosul. The trailer was partially assembled, lacking many components. Design and components were nearly identical to previously exploited 'suspect BW production' trailer. US forces located the trailer outside the main gate of Al Kindi (36°24'09.5"N 043°08'04.9"E) in a parking lot approximately 100m west of the center main gate and within 75m of the administration offices. The trailer was a dual axle flat bed with welded steel caging for walls and roof. The top caging (roof) of the trailer had been displaced in two areas. The cage above the water reservoir had been unbolted on one side and bent down to eye level. The cage above the compressor housing had been unbolted on both sides and placed on the decking of the trailer. Various components were installed or present on the trailer. From front to back, there are a water chiller with four fan housings, a motor, a large stainless steel water reservoir, a small stainless steel tank on three legs, the main stainless steel reactor, a compressor housing with compressor, and the compressor motor. Some of connections (piping) were in place

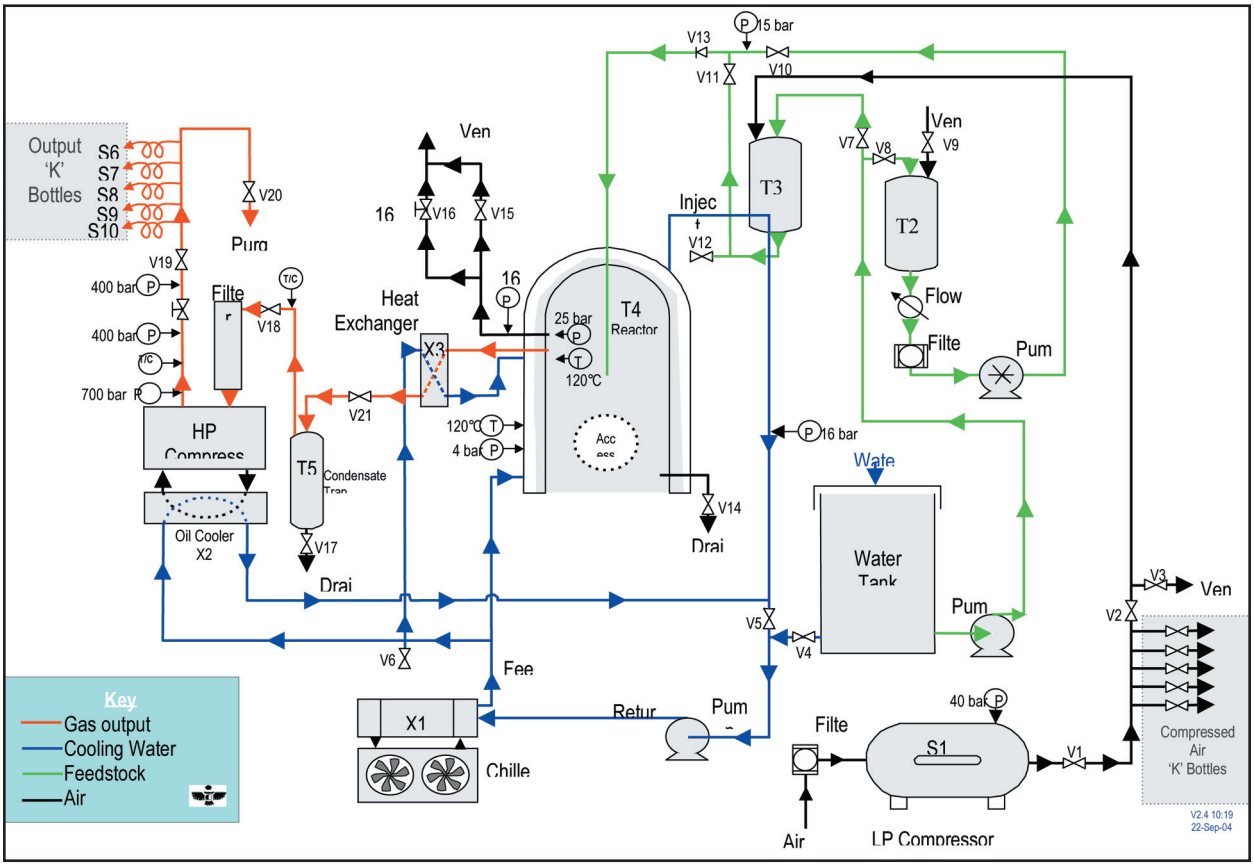

Figure 9. *Process flow diagram of trailer process.*

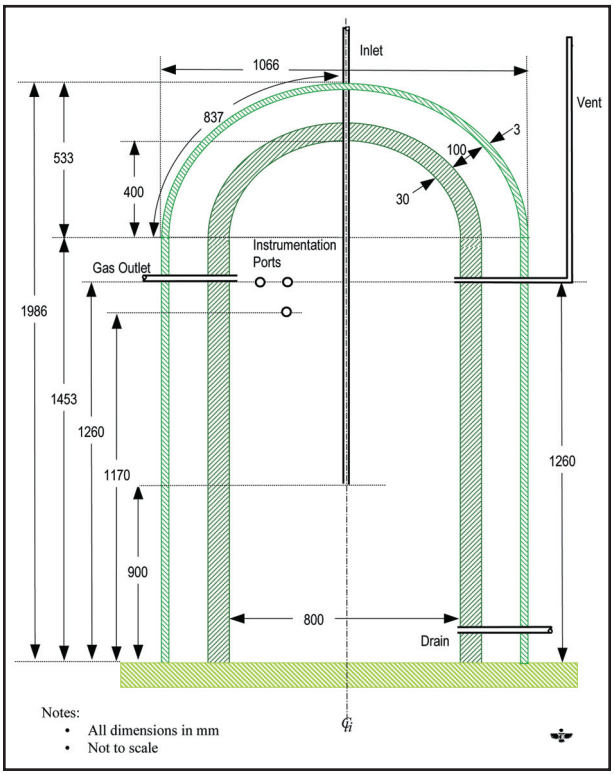

Figure 10. *Diagram of reactor.*

between components and others ended abruptly. No wiring or other electrical components were present. A number of attachment brackets were located on the decking of the trailer. The trailer appears to be a previously used armor or heavy equipment transporter. Overall layout of this trailer was very similar to the mobile trailer previously reported. The underside of the trailer had been recently painted and showed neither signs of wear nor any dirt or road debris. The trailer was found without tires and had been placed on concrete blocks.

12 May 2003. Between October 2001 and February 2003, the State Establishment for Heavy Equipments Engineering (SEHEE) fabricated two reactors, under requirements generated by the MIC. The first reactor was delivered in July 2002 to the Al Kindi State Establishment in Mosul. A modified second reactor was delivered to the same customer in January 2003. On 25 October 2001, SEHEE (Al Nasr Al Azim State Company) received a letter from MIC's Al Kindi State Establishment to fabricate two stainless steel jacketed reactors. According to the letter of request, SEHEE would receive unspecified materials from Al Kindi in Mosul. SEHEE's Ri'ad factory, building number six, received the work-order number '4/40/2001', after being processed through the company's design, technology, and planning departments. The head engineer for building number six is engineer Najm. Al Kindi dedicated engineer Mahmud Saleh as the primary coordinator on the project in an effort to emphasize the importance of the project and ensure any design or fabrication problems were quickly rectified. Mahmud Saleh visited SEHEE routinely to monitor progress and provide guidance. Reactors one and two were built using stainless steel 316 in the fabrication of both the inner and outer shells. When source asked how the first reactor performed, the Al Kindi representative indicated the reactor was 'successful.' According to the source, the first reactor was only hydrostatically tested, because reactor one's manhole diameter was too narrow for radiography equipment. During the initial hydrostatic test, reactor one was designed to withstand 100 bar. Because the source could not verify welds of reactor one with radiography, the Ri'ad factory was limited to hydrostatically testing the reactor one to 10 bar. When this was explained, Mahmud Saleh stated a 10 bar test would be sufficient, because the vessel would only contain 'hydrogen'. Subsequently, reactor two's manhole was widened to the diameter of 14 inches to allow for radiography of interior welds.

12 May 2003. Preliminary analysis of samples from the suspect transportable biological production trailer reveals negative results for chemical and biological agent signatures. An analysis with hand held assays and polymerase chain reaction (PCR) was conducted on 7 May 2003 to determine the presence of the following BW agents: anthrax, plague, Ricin, botulinum toxin, SEB, tularaemia, Brucella, and smallpox. No positive results for any BW pathogens or toxins were noted. Chemical analysis of three samples from this exploitation was conducted by the CBIST chemical laboratory using gas chromatography, mass spectrophotometry (GCMS). All samples were negative for chemical warfare agents within the detection limits of the analytical instrument (1 nanogram per microlitre).

17 May 2003. The designer of the trailers explained that the equipment was for hydrogen generation.

4 June 2003. Cover letter from DG Al Kindi to American Authority in Mosul, dated 4 June 2003, entitled *'Mobile Hydrogen Field Production System*.' The letter mentions the customer as the Republican Guard, Artillery Corps (Contract No. 73/Art/RG/2001), who required two trailers to produce hydrogen gas for meteorological station purposes. The letter also mentions the declaration to UNMOVIC of the equipment on 15 December 2002. Al Kindi offers to demonstrate the use of the equipment to generate hydrogen. The documents attached are:

–List of 10 personnel who worked on the project (5 engineers, 1 chemist and 3 technical observers).

–Technical report of 15pp on the hydrogen generators, produced in week 1 June 2003.MIC TS letter to Al Kindi dated 22 January 2003.

–Letter from Republican Guard HQ to Al Kindi 23 January 2003.

–Undated chart labeled Technical Progress.

–Project report given to UNMOVIC, dated 15 December 2002.

–Undated Republican Guard Report to Al Kindi about the tests.

–Copy of contract no. 73/MD/RG/2001 dated 23 June 2001.

–Al Kindi letter to Republican Guard discussing use of small towing vehicle, dated 5 February 2002.

–Letter from Republican Guard COS to Republican Guard Artillery Commander discussing TS correspondence of 8 January 2003 requesting an opinion on an unspecified matter in connection with the contract. Letter dated 26 February 2003.

–MIC letter to the Artillery Command of Republic Guard discussing the 11 March 2003 test results, dated March 2003 .

–Information letter, handwritten in Arabic, log of test results on 11 March 2003 with recommendations .

15 June 2003. Three sources from Al Kindi provide details of reactants and miscellaneous technical points.

Models and Military Use. The hydrogen trailer production system was modeled after the previously-used version of a mobile hydrogen gas generator, that produced hydrogen gas that was fed directly in to weather balloons without being condensed into cylinders. The model was the older hydrogen production unit that originated from Russian technology. The mobile hydrogen generation system was used instead of transporting gas cylinders into the field because it was practical and economical to produce hydrogen on site for the military. The use of the mobile unit alleviated the logistical concerns of transporting the hydrogen to the field. The system was large and heavy because it was developed and used by the Iraqi military. That is, it was designed to be durable and easily operated. No other methods of producing hydrogen gas were investigated. The trailers were modeled on a simpler version that directly produced hydrogen without condensation of the gas into cylinders. The sources did not request any outside assistance from either foreign or other Iraqi facilities for the design or manufacture of the mobile hydrogen production system.

Chemical Reaction. The production of hydrogen from aluminum, sodium hydroxide, and water was a reliable method that was previously used by the militaries in Iraq, Russia, and other countries. There were two methods in which water could enter the reactor. The first was via an air pressure system and the second was a direct feed method. Thus, the air was used only to push the water into the reactor, and it would not enter it. The water was not purified or filtered prior to use in the system.

Design. The reactor was designed specifically for the hydrogen production system. Specifically, the reactor was designed by the senior engineer and technical assistant to the director in late 2001. The reactor was constructed of stainless steel to prevent corrosion. Inlets and outlets for the various gases and liquids in the reactor were placed in accordance with the most practical locations. The reactor jacket was designed to operate in an even cooling layer to uniformly reduce the temperature within the reactor. The equipment was arrayed on the trailer in the most practical manner to ensure its effectiveness.

Products. The hydrogen was transferred from the reactor via the pipe in the top of the vessel. The two at the top are supply pipes, the one on the upper back goes to the compressor. The hydrogen it entered a filter to remove residual water and particulates, and then was compressed into the cylinders.

Safety. Safety precautions were developed during the production and handling of hydrogen. An oil-free compressor was placed on the trailer to compress the hydrogen as it was produced. The system was grounded to prevent any accidental ignition of the gas. In addition to a metal ground stake, a metal pole was attached to the trailer to act as a lightning rod to prevent sparks.

Financial Aspects. The equipment was purchased under normal purchase protocol. The reactor and low-loader were the most expensive pieces of equipment. Components were selected and purchased based on their availability in the open Iraqi market. Improvised equipment, such as the use of oxygen or nitrogen cylinders, was used instead of more difficult-to-obtain parts.

Materials. The reactant materials, including the aluminum powder and sodium hydroxide were obtained from the Iraqi market and were stored at Al Kindi. The trailers were designed to operate for several runs before cleaning, and the by-products were to be removed by scooping out the residual solids and running water through the reactor for cleaning. The hardest piece of equipment to acquire was the reactor. The delay in delivery from the production company caused the contract to be delayed for six months.

Operation. The equipment was operated based on the logical design developed by the sources. The system was to be powered by one of two methods. The first method involved the direct use of an electric source and the second method was to use a generator. The generator could be towed or located nearby the trailer, in a location that would not cause potential ignition of the hydrogen.

Transportation of the Trailers. The chassis (low loader) was used to support the weight of the equipment, and because it was readily available in the market. The system was to be pulled with a standard cab. The trailers were never moved to the test site. The cylinders containing the hydrogen produced on the trailers were the only item(s) taken to the test site. The hydrogen was used to fill meteorological weather balloons at the test site. The sources last saw both trailers at Al Kindi. The first trailer was complete and ready for delivery, and the second trailer was incomplete. The source alerted the Republican Guard to quickly come and get the complete trailer from Al Kindi, but they were never taken from Al Kindi prior to or during the war. Thus, no one used the trailers during the war.

Figure 11. *Scoop for solids.*