EFFECTS OF ACID ADDITIVES ON SPENT ACID FLOWBACK THROUGH CARBONATE CORES

A Thesis

by

EHSAAN AHMAD NASIR

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2012

Major Subject: Petroleum Engineering

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Approved by:

Chair of Committee,	A.D. Hill
Committee Members,	Ding Zhu
	Yuefeng Sun
Head of Department,	A. D. Hill

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ABSTRACT

Effects of Acid Additives on Spent Acid Flowback through Carbonate Cores. (May 2012)

Ehsaan Ahmad Nasir, B.E., NED University of Engineering and Technology
Chair of Advisory Committee: Dr. A. Daniel Hill

Matrix acidizing is a well stimulation technique used to remove formation damage in the near wellbore region. But it comes with an associated set of challenges such as corrosion of the tubulars and iron precipitation in the formation. To counter these challenges, different chemicals, or additives, are added to the acid solution such as corrosion inhibitors and iron control agents. These additives may change the relative permeability of the spent acid, and formation wettability, and may either hinder or improve spent acid clean-up. Such effects of additives on the spent acid clean-up have not been documented.

The aim of this research effort was to document the aforementioned change in the spent acid concentration (by using one additive at a time) before and after gas flowback. This was achieved by acidizing cores and creating wormholes halfway through them, then CT scanning them to observe the spent acid region. Later on, gas was flown through the core opposite to the direction of acid injection for 2 hours, and another CT scan was taken. The difference between the two CT scans was documented. Using a different additive each time, a series of such CT scans was obtained to develop an idea about whether the said additive was beneficial or detrimental to spent acid clean-up.

It was found that the corrosion inhibitor FA-CI performed the best in terms of spent acid recovery after gas flowback for both Indiana Limestone and Texas Cream Chalk cores. Moreover, the corrosion inhibitor MI-CI was the worst for Indiana Limestone and the non-emulsifying agent M-NEA the worst for Texas Cream Chalk for spent acid recovery after gas flowback.

DEDICATION

To my wife and family, who saw me through the difficult times

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. A. Daniel Hill, and my committee members, Dr. Zhu and Dr. Sun, for their guidance and support throughout the course of this research.

I'd also like to show my gratitude to my friends and colleagues and the PETE department faculty and staff for their help throughout my research effort and for making my time at Texas A&M University a fantastic academic experience.

NOMENCLATURE

ICA	Iron Control Agent
CI	Corrosion Inhibitor
NEA	Non-Emulsifying Agent
CT	Computed Tomography
Pr.	Pressure
no.	number
μ	Linear Attenuation Coefficient
I_o	Intensity of the emitted x-ray beam
I	Intensity of the detected x-ray beam
H	Thickness of the object being scanned
PPE	Personal Protective Equipment
MSDS	Material Safety Data Sheet
PVC	Polyvinyl chloride
exp.	Experiment
FA-CI	Formic Acid based Corrosion Inhibitor
MI-CI	Methanol and Isopropanol based Corrosion Inhibitor
CA-ICA	Citric Acid based Iron Control Agent
T-ICA	Trisodium nitrotriacetate based Iron Control Agent
M-NEA	Methanol based Non-Emulsifying Agent

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1. INTRODUCTION

Formation damage is a phenomenon that starts as early as drilling in the life of a well. There are several techniques that are used to rectify formation damage and stimulate the well, depending on the type of the damage. One of those well stimulation methods is acidizing, or more specifically, matrix acidizing.

In matrix acidizing, an acid (usually HCl for carbonates or an HCl/HF mixture for sandstones) is pumped down a well to remove the damage and increase permeability within a few feet of the well. The acid is pumped downhole at pressures lower than the formation's breakdown pressure i.e. the pressure at which the formation starts to fracture. The main mode of permeability increase with matrix acidizing is the chemical reaction of the acid with the minerals present downhole, which are dissolved by the acid. This is in contrast to acid fracturing, which is another technique used for well stimulation, where an acid is pumped downhole at pressures higher than the formation breakdown pressure so as to improve permeability both by the chemical reaction, and by forming a hydraulic fracture.

Wormholes are large channels, relative to pores, caused by the non-uniform dissolution

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This thesis follows the style of the journal *SPE Production and Operations.*

of carbonate formations by the acid. Unlike sandstone acidizing, in which the acid actually dissolves the formation, in carbonates the acid forms wormholes which provide a very low pressure drop thoroughfare for the fluids being produced to pass through, and flow into the wellbore.

1.1 Matrix Acidizing

Matrix acidizing, as with any other formation damage removal techniques, comes with its own set of challenges. When the acid reacts with the formation, it forms carbon dioxide and water. The chemical equations are as follows:

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

$$MgCO_3 + 2HCl \longrightarrow MgCl_2 + H_2O + CO_2$$

The reaction products actually move ahead of the wormhole forming a front, which from now on we will call the “spent acid front”. The spent acid droplets become lodged in the pores and pore throat, and serve to decrease the formation permeability by water-blocking the pores (see Fig 1.1). Furthermore, different additives are pumped along with the acid down the wellbore, which may change the wettability of the formation from water-wet to oil-wet, or vice versa.

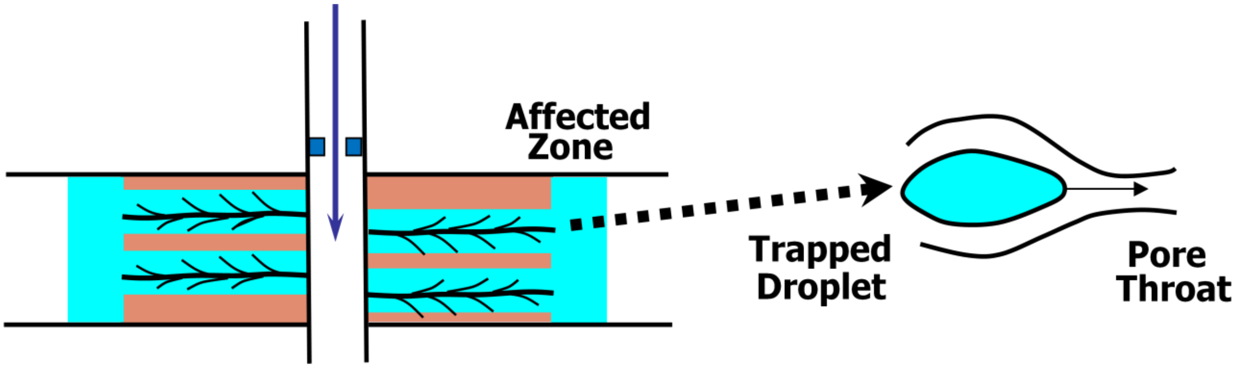

Figure 1.1 Wormholes and the spent acid region; also shown is a spent acid droplet blocking a pore throat.

A brief description of some of the additives used in matrix acidizing, along with the challenges they are used to counter, is given below:

- The downhole tubulars are susceptible to corrosion upon coming into contact with the acid, and the relatively high temperatures downhole only serve to speed up the corrosion reaction. To prevent the tubulars, valves, chokes and everything downhole that may corrode due to the acid, "corrosion inhibitors" are used. Corrosion inhibitors are one of the most important additives used in an acidizing job. Sometimes, the selection of the corrosion inhibitor may also govern the choice of the acid used, due to the costs and difficulty involved.
- Iron precipitation is also one of the mechanisms that lead to a significant permeability reduction. It is caused by the precipitation of Ferric (Fe^{3+}) ions present downhole to form Ferric Hydroxide $Fe(OH)_3$. "Iron control agents", such as EDTA (ethylenediaminetetraacetic acid), are used to prevent the Ferric ions from precipitating.

- "Non-emulsifying agents" are used to prevent emulsions from forming in the acid as it is being transferred downhole. The emulsion might hinder the reaction between the formation rock and the acid.
- Corrosion inhibitors may also change the formation wettability to oil-wet by adsorbing into the formation rock. To rectify this, "mutual solvents", such as EGMBE (ethylene glycol monobutyl ether), are used to dissolve the adsorbed corrosion inhibitor, and any acid-insoluble residue that may have been left behind as a result of the acidizing reaction.
- Many other additives are also used other than the ones mentioned, such as H_2S scavengers for capturing hydrogen sulfide, surfactants to reduce interfacial tension to speed clean-up, and diverting agents to divert the acid to desired parts of the formation.

1.2 Literature Review

Mahadevan and Sharma (2005) conducted gas displacement experiments to displace brine from a fully saturated brine rock sample. They concluded that rock type (permeability), along with several other factors such as relative permeability curves, govern how effective the water blockage clean-up is going to be. Moreover, the change in the rock's wettability from water-wet to oil-wet also caused the rock (Texas Cream limestone and Berea sandstone) to clean up faster.

Kamathe and Laroche (2003) addressed the decrease in gas well productivity due to water blockage by carrying out experiments using different fluids and saturation states. Their results show that water blockage is a transient phenomenon that depends on the amount and type of the fluid lost, gas flowrate, and the pressure drawdown in the reservoir. The gas deliverability was found to recover in two phases: the first phase is the liquid production which lasts for a few hours; the second phase is evaporation of the water blocked region with continuous gas flow and takes several days. Adding methanol to the fluid resulted in drastically reducing the time required for the second phase.

Nasr-El-Din et al. (2004) documented experimental studies carried out to observe the change in surface tension of HCl-based stimulation fluids. Similarly, Saneifar et al. (2011) discussed the effects of high pressure and temperature on the surface tension of spent acids. But so far, there hasn’t been any work done that touches on how effectively the water blockage effects of spent acid are removed, and what is the effect, if any, of different stimulation fluids on the spent acid clean-up. That is what will be addressed in this study.

2. PROBLEM DEFINITION

2.1 Description of the Problem

Several different additives are used in acidizing to tackle challenges encountered downhole, but the truth is that these additives may also alter the formation properties such as permeability and wettability. Hence, the selection process of additives has to include the upsides and downsides associated with each additive, and how they stack up in order to achieve the ultimate goal of stimulating the damaged well.

In matrix acidizing, the spent acid (which is the name given to the reaction products of the acidizing reaction plus the unused acid) actually penetrates farther into the formation than the wormholes. The spent acid may block pores and pore throats by clogging them with water droplets. Some of it may flow back during the initial phase of production of a well, along with the fluids being produced and a rather efficient clean-up may be achieved. But depending on the acid additives being used (and their effect on the formation wettability) the spent acid clean-up might not be significant and it might keep blocking the pores, or change the wettability of the rock near the wellbore, thereby causing a decrease in relative permeability and hence production.

The goal of this study is to experimentally simulate and document this process, i.e. the change in formation properties caused by the additives used resulting in an inefficient spent acid clean-up, that may lead to a decrease in relative permeabilities of the fluids flowing through the formation, and hence and overall decrease in production.

2.1.1 CT Scanning Theory and Beam Hardening

When an object is CT scanned, it is bombarded by x-rays from different angles by an x-ray source. The sources revolve around the object to be scanned and the transmitted x-rays intensity is measured by a series of detectors. The main quantity measured is the linear attenuation coefficient **μ**, which is related to the incident x-ray intensity **I_o** by Beer's law as:

$$I / I_o = exp^{-\mu h}$$

where **I** is the intensity of the x-ray after it has passed through the object being scanned, and **h** is the thickness of the scanned object.

Beer's law assumes that the x-ray beam used to scan the object was monochromatic i.e. it has a single frequency. That is not the case in reality, and the x-ray beams are polychromatic. This causes low energy x-ray photons to be absorbed more readily at the air-object interface and also by the object itself. This leads to an error in the determination of the linear attenuation coefficient μ called "beam hardening". For a cylindrical object such a core, the error shows up as higher CT numbers in the periphery of the core and lower CT numbers at the center.

Akin and Kovscek (2003) suggested that beam hardening can be corrected by surrounding the coreholder with a cylindrical water-jacket, or with a crushed-rock jacket, or using aluminum and composite carbon-fiber coreholders.

3. EXPERIMENTAL PROCEDURE

In this section, we will discuss the procedure followed to obtain the results shown. We will first describe the acidizing and the flowback apparatus and how it is set up, the CT scanning procedure used to visualize the changes in the core during various phases of the experiment, then the additives employed in this study, and finally the actual procedure of how the experiments were carried out.

3.1 Acidizing and Flowback Apparatus

For the purpose of our study, we used a basic coreflood apparatus, which is comprised of the following parts:

- A syringe pump (Fig 3.1), which provides the driving force to push the fluids trough the acidizing apparatus. The pump forces hydraulic oil through the interconnecting tubes. The oil in turn pushes on a piston housed in a component called accumulator. On the other side of the piston is the fluid to be pumped.
- An accumulator (Fig 3.2), which holds the fluid that is to be pumped through the acidizing apparatus.
- A PVC container (Fig 3.3), which is used to refill the accumulator with the fluid to be pumped. The fluid is first poured into the PVC container, and then is forced pneumatically into the accumulator.

Figure 3.1 Teledyne ISCO 500D syringe pump

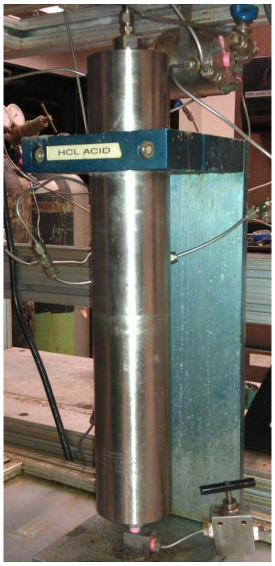

Figure 3.2 Acid accumulator

Figure 3.3 PVC refill container

- A coreholder (Fig 3.4), which holds the core housed in a Hessler sleeve, through which the desired fluid is to be pumped.
- An overburden pump (Fig 3.5), which is used to simulate overburden pressure, by pressuring oil around the Hessler sleeve inside the coreholder. The sleeve, in turn, grips the core tightly, and compressing it as overburden would.

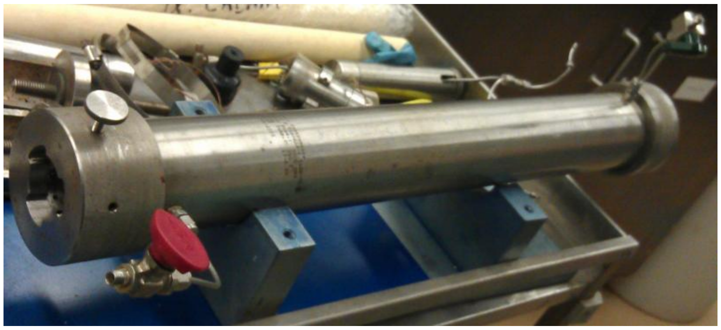

Figure 3.4 TEMCO stainless steel coreholder

Figure 3.5 ENERPAC hand pump

- A back pressure regulator (Fig 3.6), to keep the pressure at the coreholder's outlet at a desired value. It's also used to keep the pressure inside the coreholder high enough to ensure the carbon dioxide produced as a result of the acidizing reaction remains dissolved in solution.
- Pressure transducers (Fig 3.7), hooked up to a computer, to monitor the pressure drop across the core.

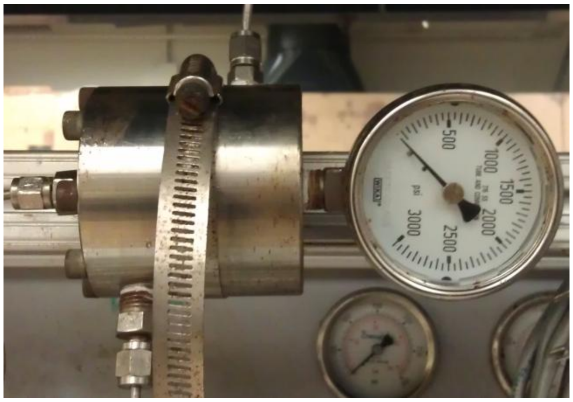

Figure 3.6 Mity-Mite back pressure regulator

Figure 3.7 FOXBORO pressure transducer

- A gas flowmeter (Fig 3.8), to measure the gas flowrate at the outlet of the acidized cores.
- Nitrogen cylinders (Fig 3.9) were used as the source of the gas that will flow through the acidized cores.

Figure 3.8 OMEGA gas volume flowmeter

Figure 3.9 Industrial grade-nitrogen cylinders

All these components are connected together with 1/8 inch steel tubing (as seen in Fig 3.10). Hastelloy tubings are preferred for connecting those components through which the acid will flow, as it is more resistant to corrosion. The rest of the components are connected with regular stainless steel tubing.

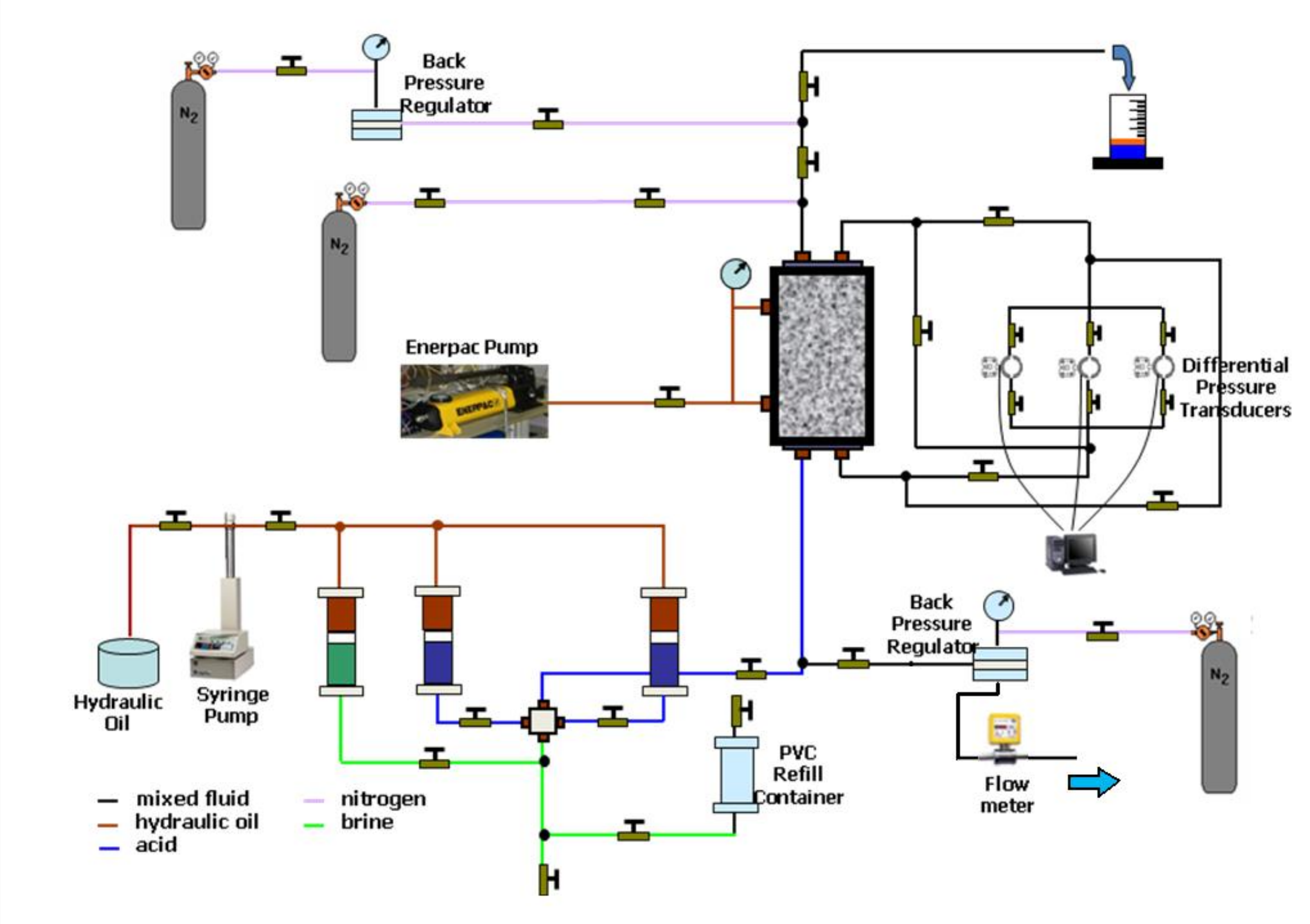

Figure 3.10 Schematic of the acidizing and flowback apparatus; a modified version of the one used by Nevito (2006)

3.2 CT Scanner

The CT scanner (Fig 3.11b) was used three times during the course of a single experiment. Beam hardening was seen in the initial scans which cause the CT numbers at the edges of a CT scan to be higher than at the center. A ¾ inch thick and 21 inches long hollow aluminum cylinder (see Fig 3.11a) was used to encase the cores during CT scans to remove beam hardening from the results.

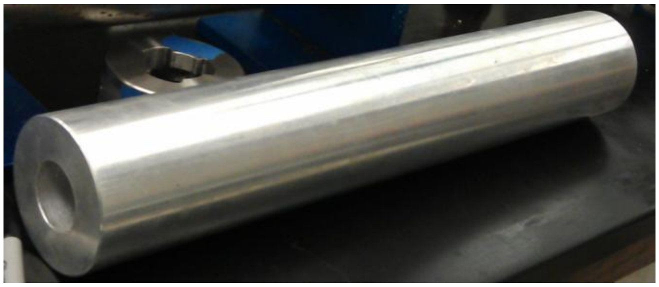

Figure 3.11a Hollow aluminum cylinder; for encasing cores during CT scans to remove beam hardening

Figure 3.11b CT Scanner

3.3 Description of the Cores

Indiana Limestone (Fig 3.12a) and Texas Cream Chalk (Fig 3.12b) carbonate cores were used in the study. The cores were 1.5 inch in diameter and 20 inch in length. The permeability for both types of cores was in the 1 to 10 md range.

Figure 3.12a Indiana Limestone core

Figure 3.12b Texas Cream Chalk core

3.4 Acid Additives

The following acid additives were used in this study:

- A formic acid based corrosion inhibitor, which for the purpose of this study will be called **FA-CI** (Fig 3.13). It is a liquid, dark reddish-brown in color with a sharp odor. It is also flammable in nature. It was found that FA-CI plugs the 1/8" tubings coming out of the PVC refill container which had to be replaced later on.
- A methanol and isopropanol based corrosion inhibitor, which for the purpose of this study will be called **MI-CI** (Fig 3.14). It is also a liquid, with a dark red-amber color and an alcoholic odor. It is also flammable. Similar to FA-CI, MI-CI also plugs the 1/8" tubings coming out of the PVC refill container.

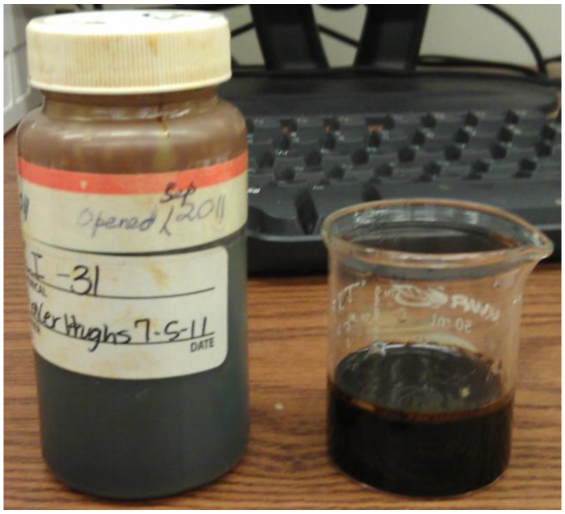

Figure 3.13 Corrosion inhibitor FA-CI

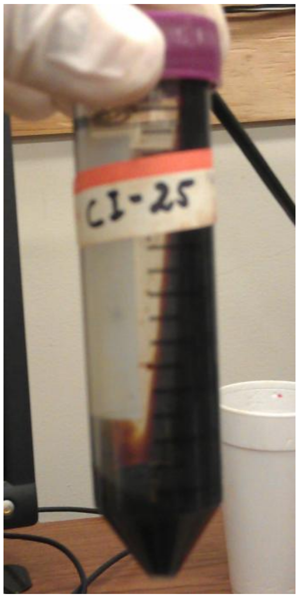

Figure 3.14 Corrosion inhibitor MI-CI

- A citric acid based iron control agent, which for the purpose of this study will be called **CA-ICA** (Fig 3.15). It is originally in the form of powder or granules, and is odorless. It is not flammable.
- A trisodium nitrotriacetate (trisodium NTA) based iron control agent, which for the purpose of this study will be called **T-ICA** (Fig 3.16). It is a liquid, pale yellow in color with a slight ammonia odor. It is a combustible compound.

Figure 3.15 Iron control agent CA-ICA

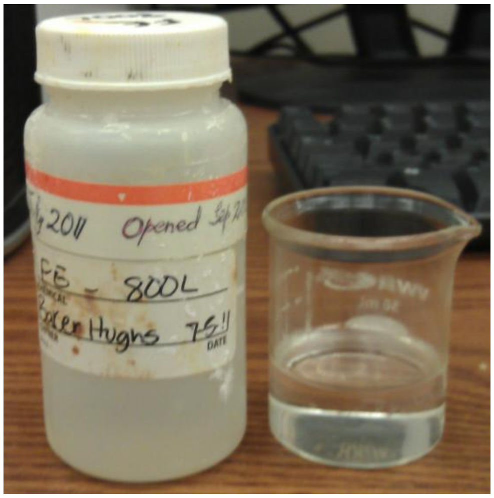

Figure 3.16 Iron control agent T-ICA

- A methanol based non-emulsifying agent, which for the purpose of this study will be called **M-NEA** (Fig 3.17). It is a colorless liquid, and has a sweet smell. It is also flammable.

All these additives were obtained from BJ Services (now a part of Baker Hughes). The additives are all toxic. Proper PPEs should be used when handling them as mentioned in their respective MSDS.

Moreover, a radio opaque salt (or tracer) sodium iodide NaI (Fig 3.18) was added to the acid solution to increase the contrast between gas-saturated and spent acid-permeated areas in a core during CT scans.

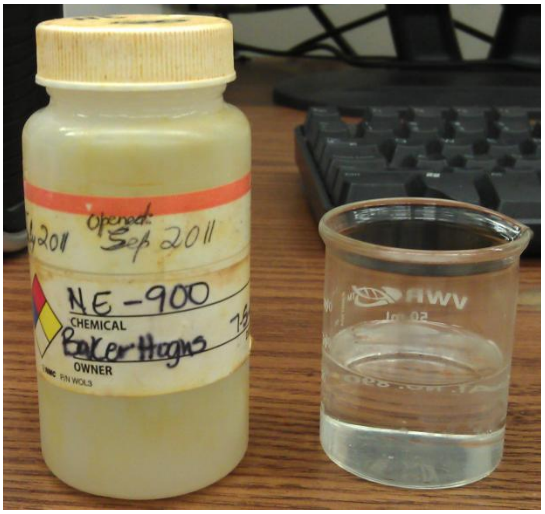

Figure 3.17 Non-emulsifying agent M-NEA

Figure 3.18 Sodium Iodide

3.5 Acidizing and Gas Flowback Procedure

The procedure is composed of the following steps:

- Take a carbonate core and determine its permeability to gas. By applying a back pressure at the core's outlet when finding the gas permeability, the gas slippage effect can be eliminated leading to an accurate (and lower) determination of the permeability (Li et al., 2004).
- The gas saturated core is then CT scanned to serve as a control for future scans. This is the base scan to which future scans will be compared with to determine the extent the spent acid has permeated in the core. We will call this scan the "Gas saturated" scan.
- Next, a 15 wt% HCl solution is prepared for acidizing the cores. To this solution, 2 wt% of the additive being tested and 5 wt% of sodium iodide is added. The sodium iodide gives a yellow color to the acid solution (Fig 3.19).

Figure 3.19 A 15 wt% HCl solution with 2 wt% NaI added

- Before acidizing, the acidizing apparatus is first flushed with water to rid it of any contaminants present in the system.
- Before starting the experiment, make sure that there is no air in the pump and the apparatus.
- The acid solution prepared earlier is pushed pneumatically into the accumulator; this is done by pouring the acid solution into the PVC container and using the lab air supply to push it into the accumulator. Afterwards again make sure that there is no air in the system.
- Place the core to be acidized in the coreholder, and connect the coreholder to the acidizing apparatus.
- Pump oil into the coreholder using the hand pump to simulate the overburden pressure. The overburden pressure should be at least 200-300 psi higher than the core outlet pressure. This is to ensure that the acid actually goes through the core instead of flowing through the area between the core and the Hessler sleeve.
- Next, pressurize the back pressure regulator connected to the outlet of the coreholder to a 1000 psi. This will ensure that the flow will only occur through it once the pressure at the core outlet is larger than 1000 psi. It also ensures that the CO_2 formed as a result of the acidizing reaction remains in solution.
- Acid is then pumped at the rate of 8 ml/min (or cc/min) all the while recording the pressure drop across the core measured by the pressure transducers. In our case this function was performed by LabVIEW.

- Let the acid flow for around 5-7 minutes. Usually for Indiana Limestone the pressure drop across the core should be above 500 psi. For Texas Cream Chalk it should be above 200 psi. This would ensure that the wormhole has penetrated a sufficient distance into the core to begin the next phase of experiment.
- After pumping acid for 5-7 minutes, stop the pump.
- Depressurize the apparatus starting with the core inlet and then overburden and lastly the back pressure regulator.
- Take the core out of the core holder and encase it in the hollow aluminum cylinder. Fig 3.20 shows what an acidized core looks like.
- CT scan the acidized core for a second time. This scan will show us how far the spent acid front has travelled inside the core. We will call this scan the “ After acidizing” scan.
- Flush the whole apparatus again with water to ensure there is no acid left in the apparatus.

Figure 3.20 Inlet faces of acidized Indiana Limestone (left) and Texas Cream Chalk (right) cores

- After the second scan, put the core in the core holder again and prepare the apparatus for gas flowback. Make sure the direction of gas flow is opposite to that of the acid flow. The core outlet during acid injection will become the inlet for gas injection and vice versa.
- Also connect the back pressure regulator to the gas injection core outlet and pressurize it up to 300 psi. This will mimic the Bottom Hole Pressure.
- Connect a gas flow meter to the outlet of the back pressure regulator to gage the gas flow rate at atmospheric conditions (or standard conditions).
- Ensure the gas inlet pressure is high enough (800-1000 psi in our case) to have a gas flow rate of at least 3L/min. This value, of course, will depend on the core's gas permeability and the length of the wormhole.
- Let the gas flowback continue for 2 hours, then stop the gas supply.
- Depressurize the gas pressure regulator and then the overburden.
- Once the apparatus has been depressurized, take the core out from the core holder.
- Put the core in the hollow aluminum cylinder and CT scan it for the third time. We will call this scan the "After flowback" scan.
- We will now look at the three CT scans and see how much the spent acid front has been pushed back for 2 hours of gas flowback.

3.6 CT Scanning Procedure

The procedure for CT scanning is as follows:

- Encase the core to be scanned in a hollow aluminum cylinder to get rid of beam hardening.
- Before placing the encased core in the CT scanner, make sure that the surface it’s being placed on is perfectly horizontally with the help of a level gage.
- We used the following parameters for the scan:
  - Image size: 120
  - Index: 4 mm; this is the distance between two consecutive scans.
  - Thickness of the beam: 2mm; this means that a slice 2 mm thick will be scanned.
  - Number of scans: 125; a single 20 inches long core will have 125 slices in a single scan.
- Make sure to preheat the CT scanner before starting the scan.
- If the CT scanner heats up above its specified limit, stop the scan.
- Wait for the CT scanner to cool down, and then restart the scan.

Because of beam hardening errors, several works were studied to formulate a correct acidizing and CT scanning methodology, including Al-Muthana and Okasha (2008), Angulo and Ortiz (1992), Bartko (1995), Coles et. al (1996), Hove et. al (1987), Hunt et. al (1988), Wellington and Vinegar (1987), Withjack (1988) and Withjack et.al (2003).

4. EXPERIMENTAL RESULTS

4.1 Comparison of Mean CT Numbers Before and After Gas Flowback

In the section we will compare the CT number obtained from the three different scans performed in a single experiment. Each plot will have three curves, namely:

- “Gas saturated”, which comprises of the CT numbers of the gas saturated core before being acidized
- “After acidizing”, which comprises of the CT numbers of the core after being acidized, and
- “After flowback”, which comprises of the CT numbers of the acidized core after gas has been flown through it for 2 hours.

Another way to look at the results is a “Difference Plot” which is simply found out by subtracting the CT numbers after flowback from the CT numbers after acidizing (or before gas flowback). In these plots the magnitude of the peaks obtained is directly proportional to the drop in CT numbers after gas flowback i.e. how much the spent acid front has been pushed back and cleared up by the produced gas.

Constant backpressure and overburden pressure were used throughout the acidizing experiments, and their values are tabulated as under (Table 4.1):

TABLE 4.1-BACK PRESSURE AND OVERBURDEN PRESSURE VALUES

1	Back pressure	1000	psi
2	Overburden pressure	1500	psi

4.1.1 Indiana Limestone

Six experiments were performed in total with Indiana Limestone cores. One experiment was done without any additive to serve as a control. The results are as under:

4.1.1.1 No additive

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.2a, 4.2b and 4.2c):

TABLE 4.2a-ACID FLOW PARAMETERS (INDIANA LIMESTONE; NO ADDITIVE)

1	Acid Injection Rate	8	cc/min		
2	Injection time	10	Min	30	sec

TABLE 4.2b-ACID FORMULATION (INDIANA LIMESTONE; NO ADDITIVE)

1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g

TABLE 4.2c-FLOWBACK PARAMETERS (INDIANA LIMESTONE; NO ADDITIVE)			
1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	800	psi
4	Pr. drop across the core	523	psi
5	Flowrate	19.5	L/min
6	Flow time	45	min
7	Flow meter zero error	0.5	L/min

The plot of mean CT numbers after acidizing and after flowback can be seen below (Fig 4.1a). The recession of the spent acid front is visible in the area marked “Region of interest”. The end of the wormhole is also mentioned in the plot.

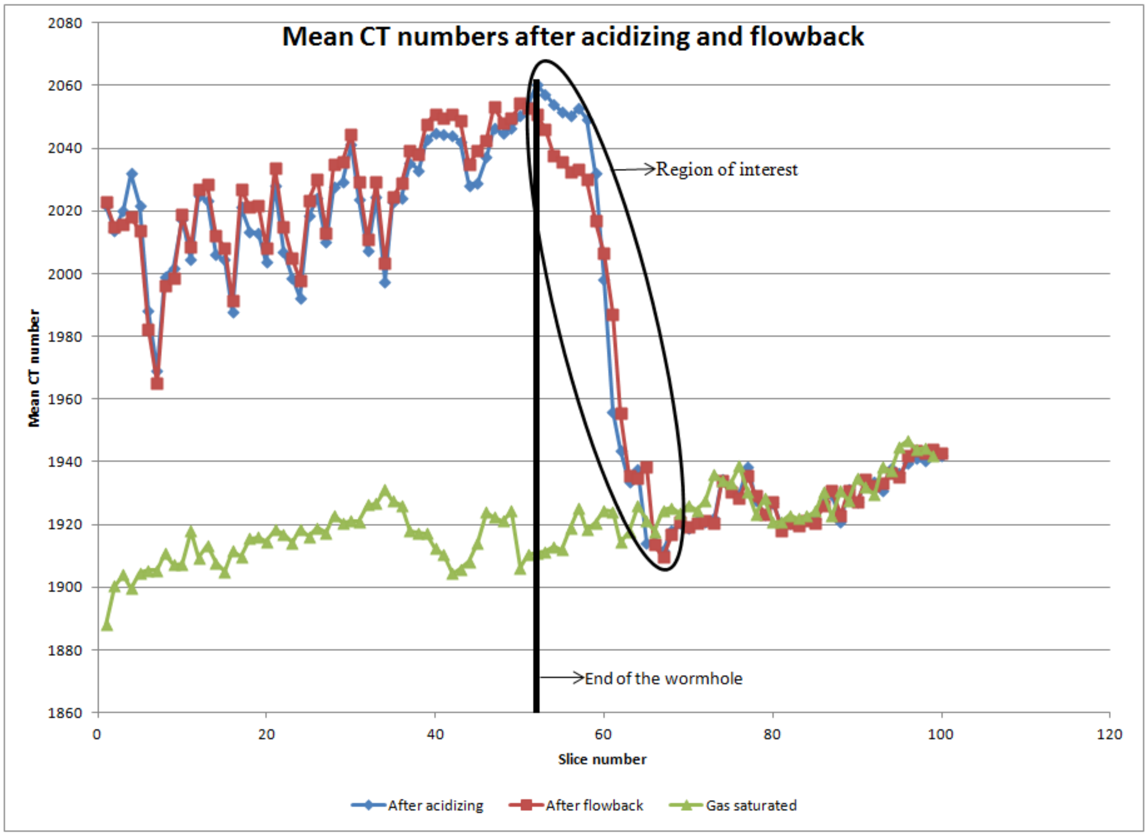

Figure 4.1a Mean CT number plot for Indiana Limestone (no additive)

The Difference plot plots the difference in CT numbers after acidizing and after flowback (see Fig 4.1b). Positive peak shows the recession of the spent acid front with the magnitude of the peak corresponding to how much of the spent acid has been produced during flowback.

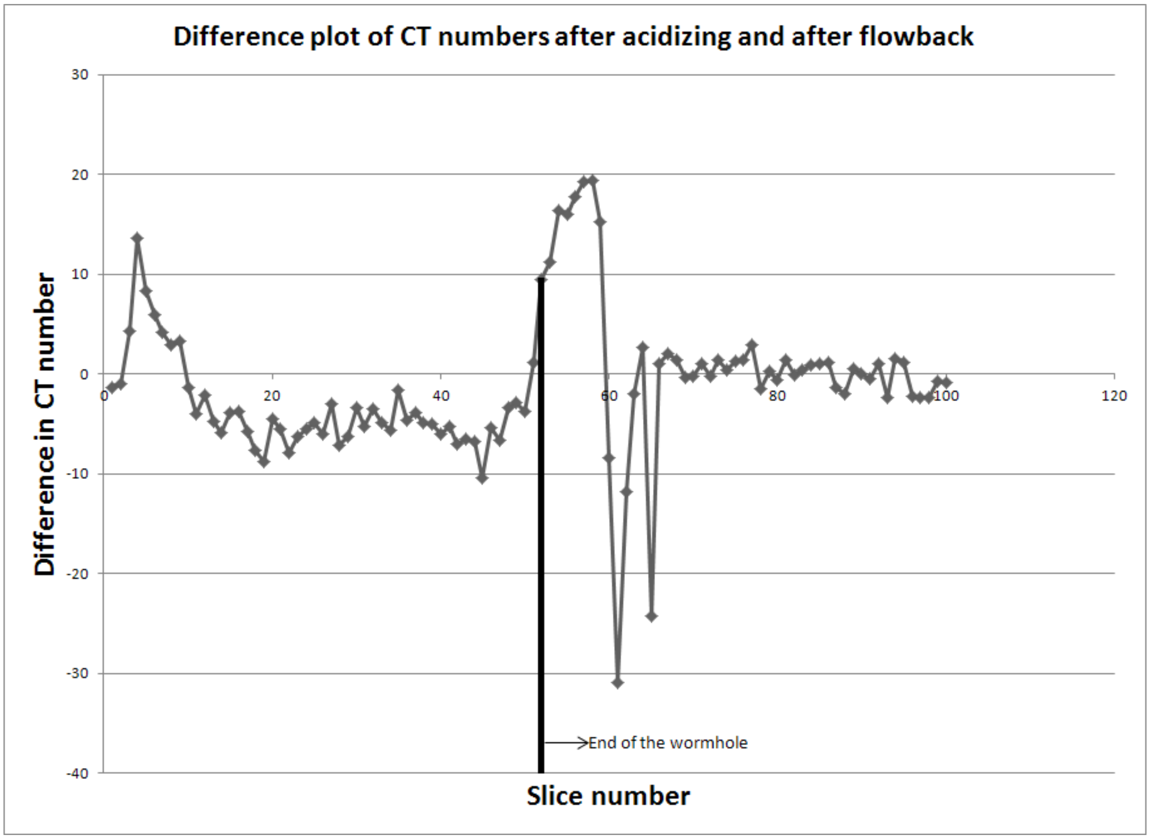

Figure 4.1b Difference plot for Indiana Limestone (no additive)

4.1.1.2 T-ICA

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.3a, 4.3b and 4.3c):

TABLE 4.3a-ACID FLOW PARAMETERS (INDIANA LIMESTONE; T-ICA)					
1	Gas Permeability	3.4	md		
2	Acid Injection Rate	8	cc/min		
3	Injection time	9	min	30	sec

TABLE 4.3b-ACID FORMULATION (INDIANA LIMESTONE;T-ICA)

1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	T-ICA (2 wt%)	6.3	g

TABLE 4.3c-FLOWBACK PARAMETERS (INDIANA LIMESTONE;T-ICA)

1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	800	psi
4	Pr. drop across the core	435	psi
5	Flowrate	5.7	L/min
6	Flow time	120	min
7	Flow meter zero error	0.5	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.2a) and the Difference plot (Fig 4.2b) are seen below.

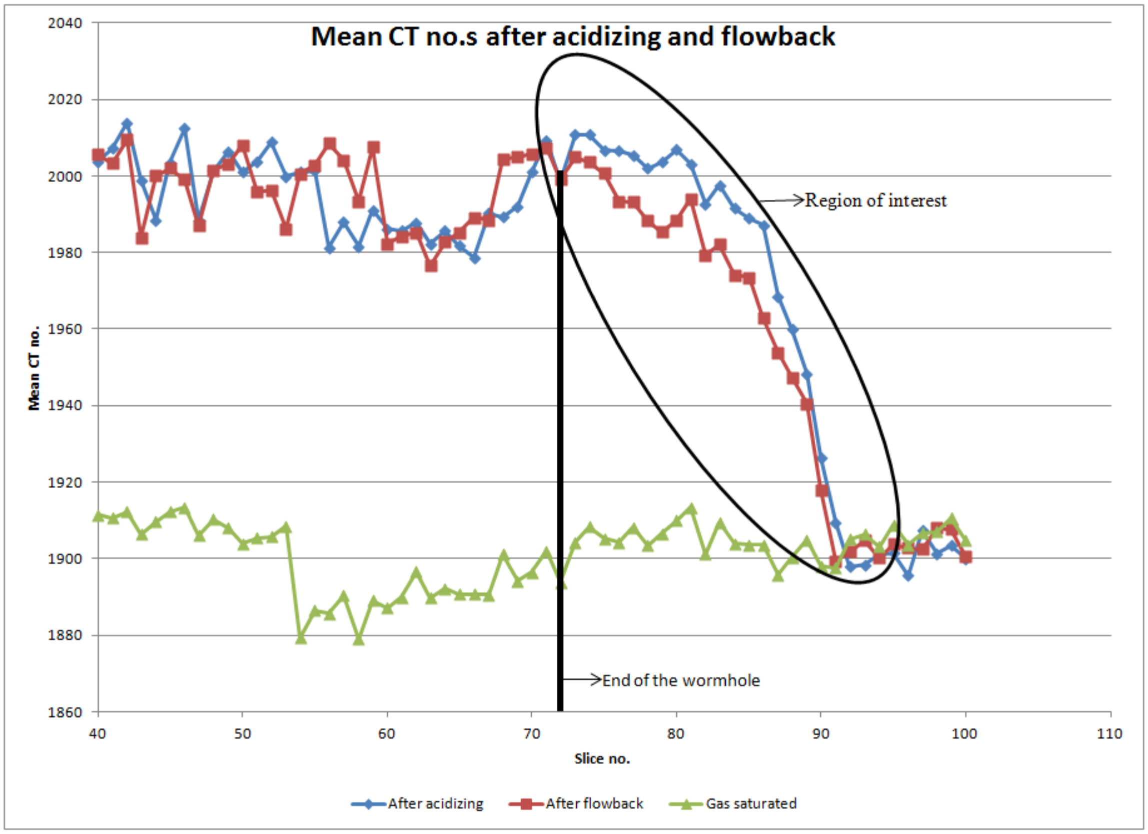

Figure 4.2a Mean CT number plot for Indiana Limestone (T-ICA)

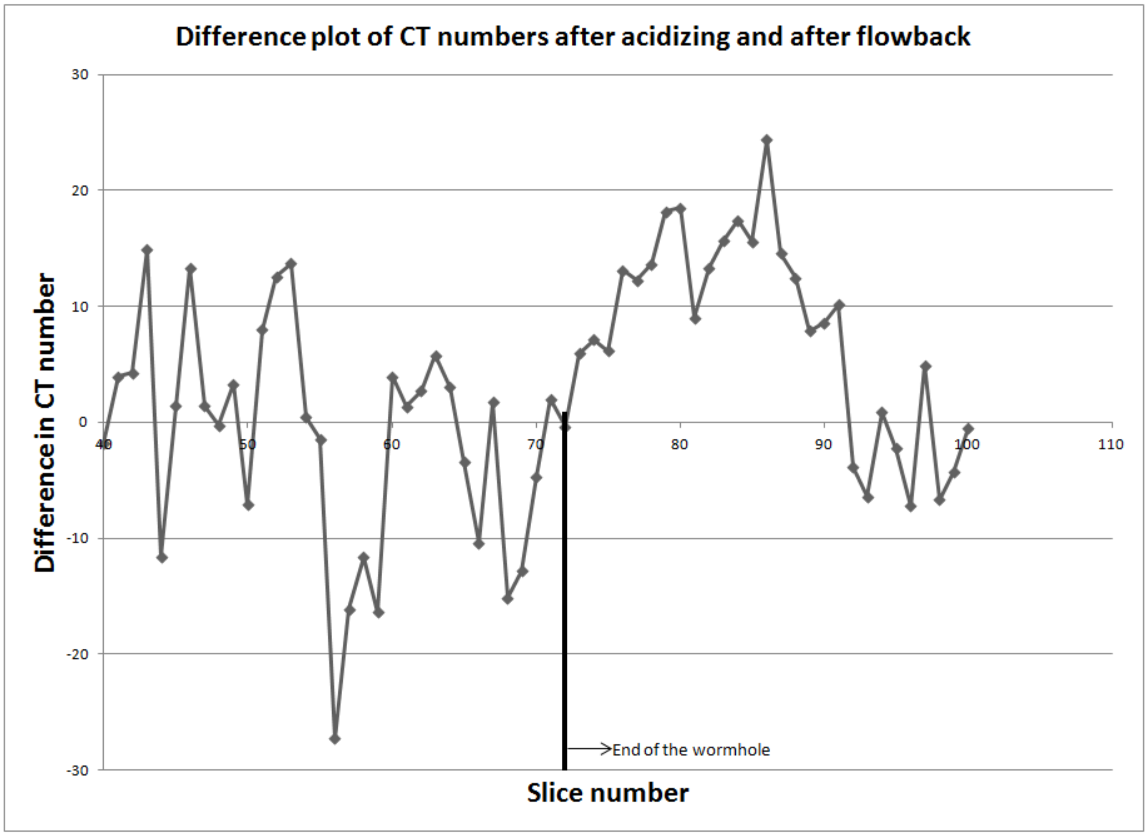

Figure 4.2b Difference plot for Indiana Limestone (T-ICA)

4.1.1.3 CA-ICA

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.4a, 4.4b and 4.4c):

TABLE 4.4a-ACID FLOW PARAMETERS (INDIANA LIMESTONE; CA-ICA)

1	Gas Permeability	1.2	md		
2	Acid Injection Rate	8	cc/min		
3	Injection time	5	min	20	sec

TABLE 4.4b-ACID FORMULATION (INDIANA LIMESTONE; CA-ICA)

1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	CA-ICA (2 wt%)	6.3	g

TABLE 4.4c-FLOWBACK PARAMETERS (INDIANA LIMESTONE; CA-ICA)

1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	1100	psi
4	Pr. drop across the core	743	psi
5	Flowrate	1.5	L/min
6	Flow time	120	min
7	Flow meter zero error	0.4	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.3a) and the Difference plot (Fig 4.3b) are seen below.

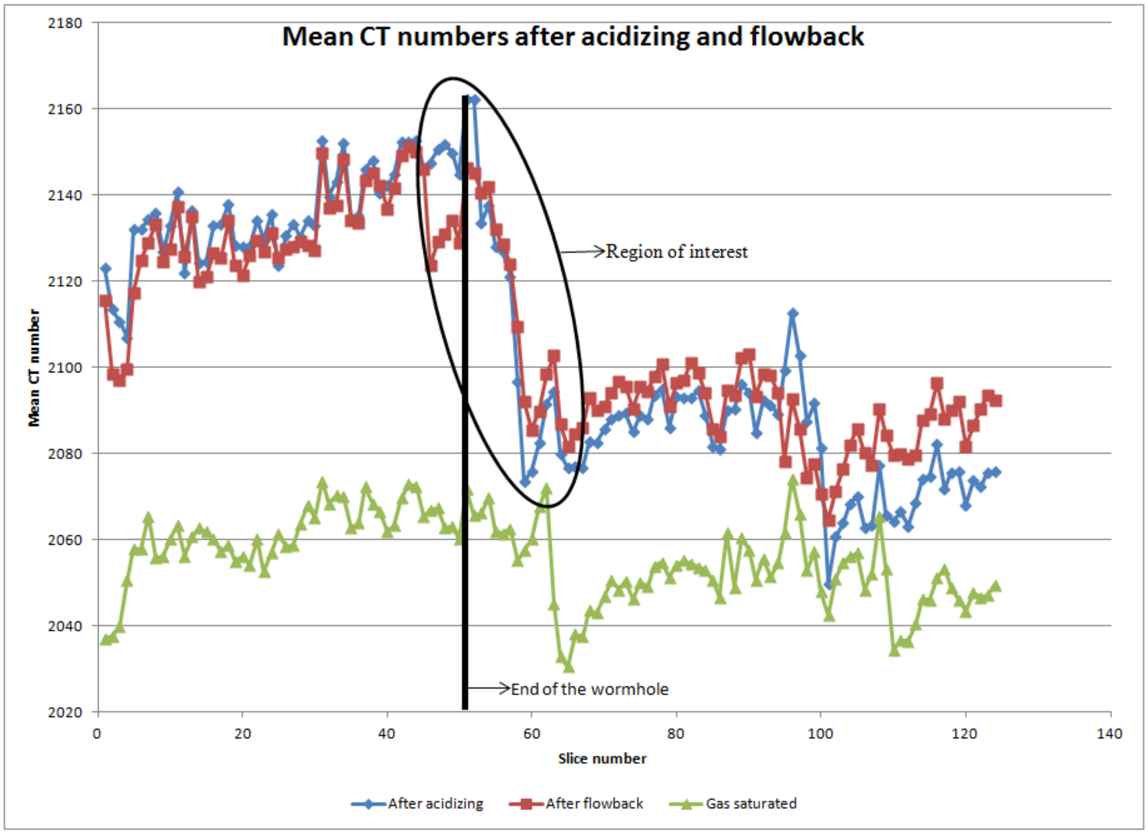

Figure 4.3a Mean CT number plot for Indiana Limestone (CA-ICA)

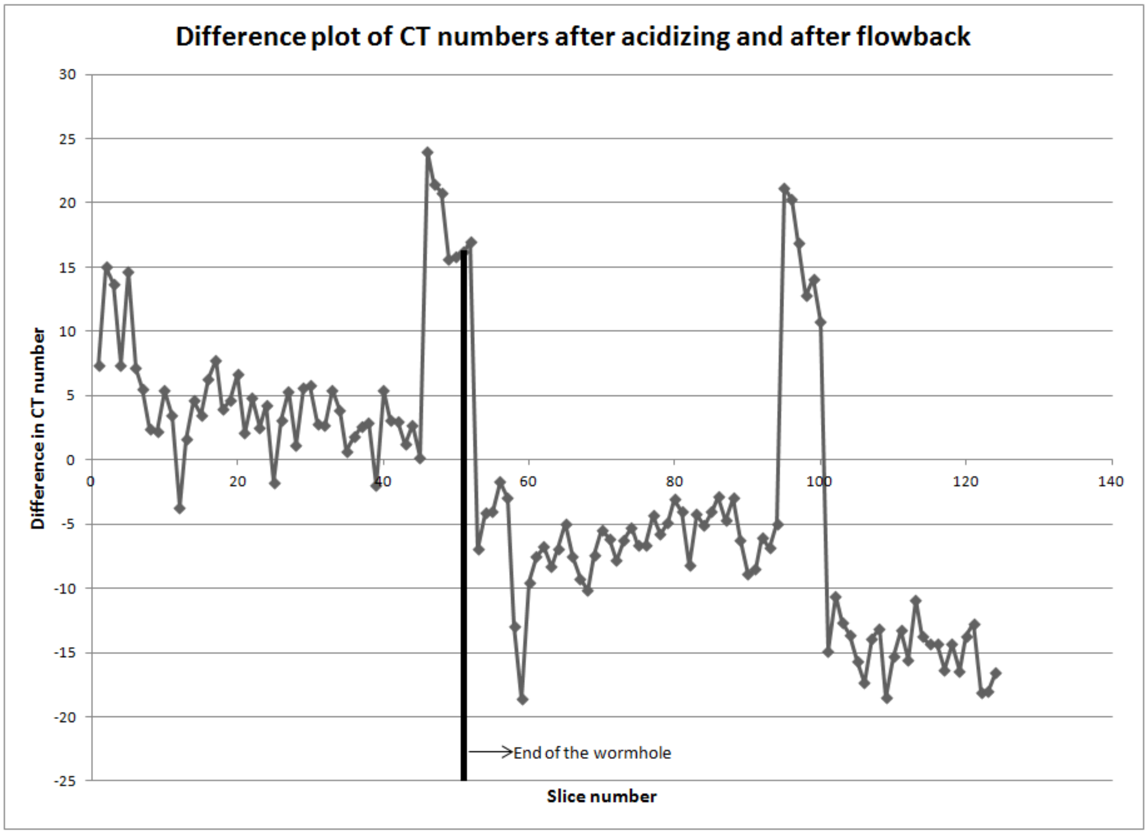

Figure 4.3b Difference plot for Indiana Limestone (CA-ICA)

4.1.1.4 FA-CI

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.5a, 4.5b and 4.5c):

TABLE 4.5a-ACID FLOW PARAMETERS (INDIANA LIMESTONE; FA-CI)					
1	Gas Permeability	3.3	md		
2	Acid Injection Rate	8	cc/min		
3	Injection time	11	min	30	sec

TABLE 4.5b-ACID FORMULATION (INDIANA LIMESTONE; FA-CI)			
1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	FA-CI (2 wt%)	6.3	g

TABLE 4.5c-FLOWBACK PARAMETERS (INDIANA LIMESTONE;FA-CI)			
1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	800	psi
4	Pr. drop across the core	460	psi
5	Flowrate	15.0	L/min
6	Flow time	120	min
7	Flow meter zero error	0.4	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.4a) and the Difference plot (Fig 4.4b) are seen below.

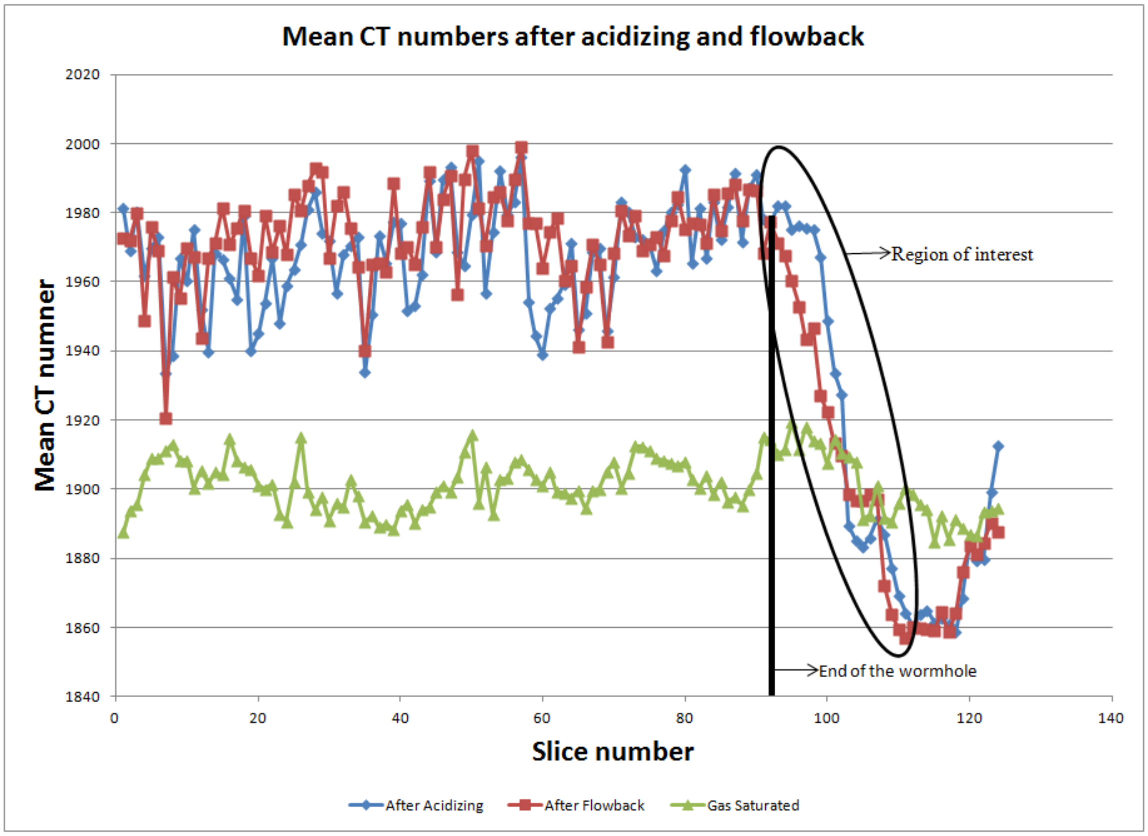

Figure 4.4a Mean CT number plot for Indiana Limestone (FA-CI)

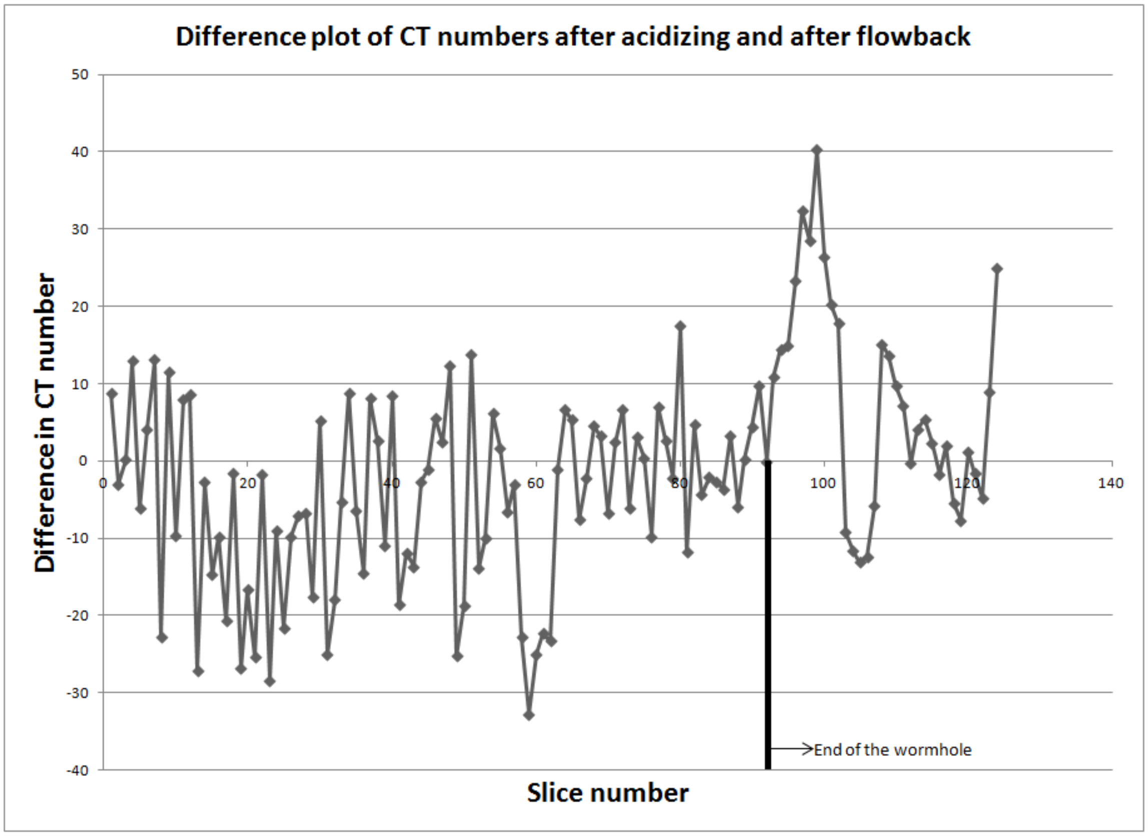

Figure 4.4b Difference plot for Indiana Limestone (FA-CI)

4.1.1.5 MI-CI

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.6a, 4.6b and 4.6c):

TABLE 4.6a-ACID FLOW PARAMETERS (INDIANA LIMESTONE; MI-CI)					
1	Gas Permeability	1.8	md		
2	Acid Injection Rate	8	cc/min		
3	Injection time	5	min	20	sec

TABLE 4.6b-ACID FORMULATION (INDIANA LIMESTONE; MI-CI)			
1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	MI-CI (2 wt%)	6.3	g

TABLE 4.6c-FLOWBACK PARAMETERS (INDIANA LIMESTONE; MI-CI)			
1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	1100	psi
4	Pr. drop across the core	743	psi
5	Flowrate	2.5	L/min
6	Flow time	120	min
7	Flow meter zero error	0.4	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.5a) and the Difference plot (Fig 4.5b) are seen below.

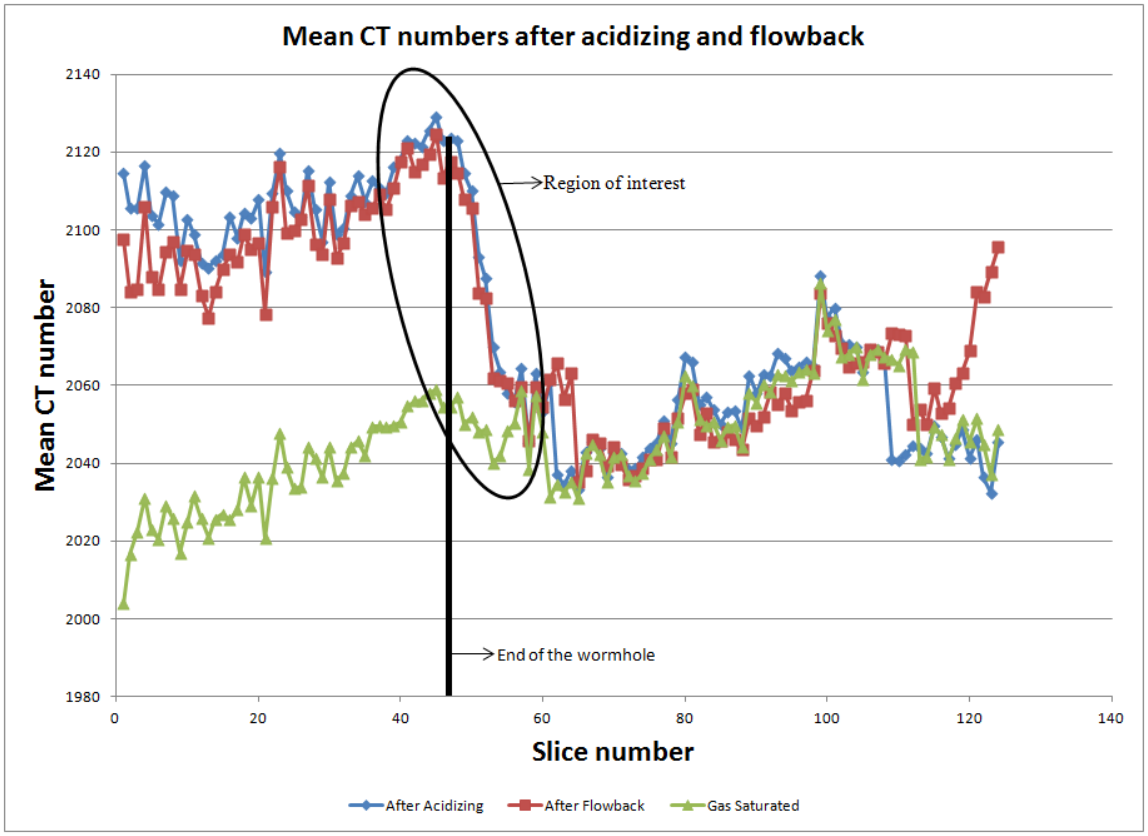

Figure 4.5a Mean CT number plot for Indiana Limestone (MI-CI)

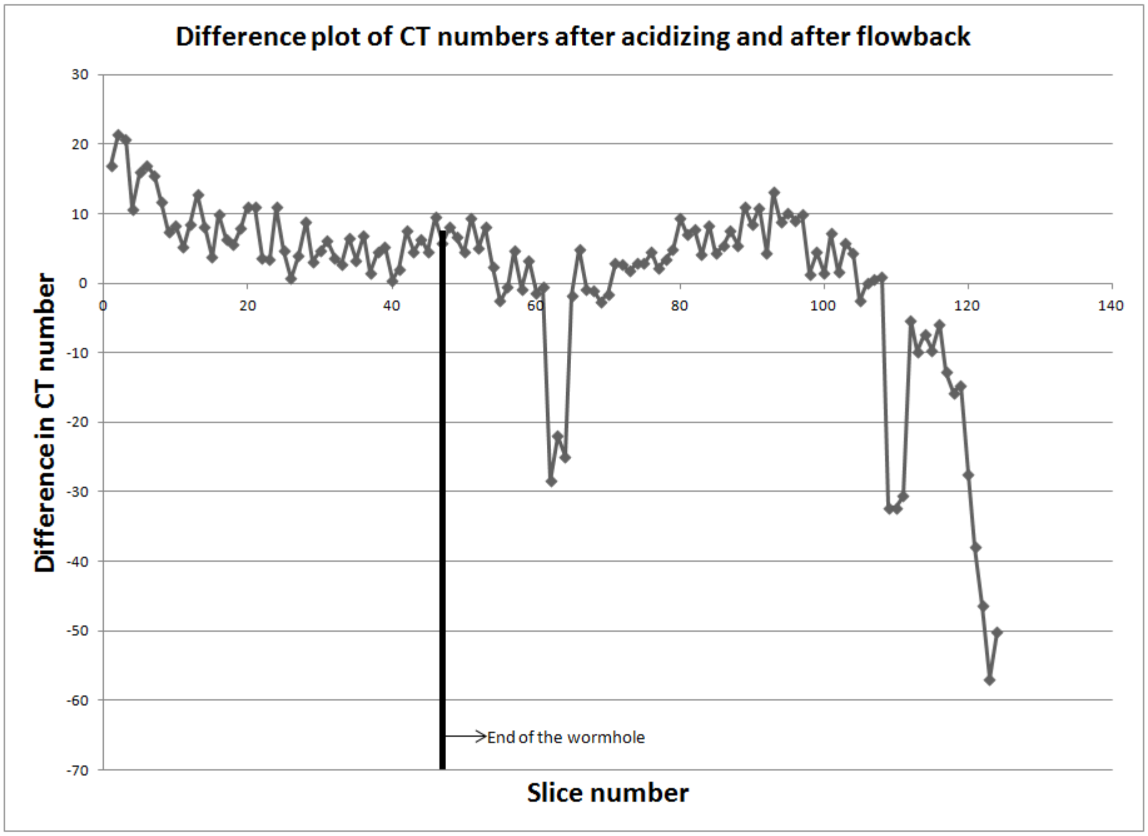

Figure 4.5b Difference plot for Indiana Limestone (MI-CI)

4.1.1.6 M-NEA

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.7a, 4.7b and 4.7c):

TABLE 4.7a-ACID FLOW PARAMETERS (INDIANA LIMESTONE; M-NEA)

1	Gas Permeability				
2	Acid Injection Rate	8	cc/min		
3	Injection time	5	min	30	sec

TABLE 4.7b-ACID FORMULATION (INDIANA LIMESTONE; M-NEA)

1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	M-NEA (2 wt%)	6.3	g

TABLE 4.7c-FLOWBACK PARAMETERS (INDIANA LIMESTONE; M-NEA)

1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	800	psi
4	Pr. drop across the core	452	psi
5	Flowrate	3.3	L/min
6	Flow time	120	min
7	Flow meter zero error	0.4	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.6a) and the Difference plot (Fig 4.6b) are seen below.

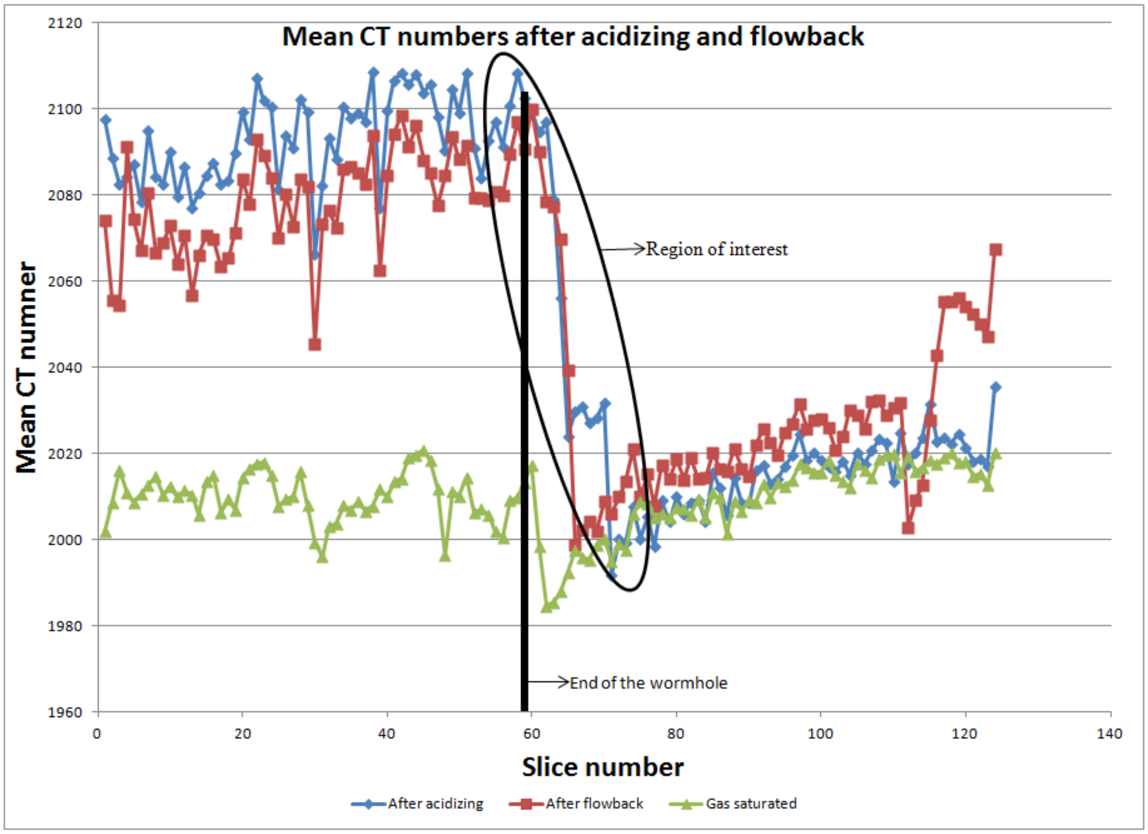

Figure 4.6a Mean CT number plot for Indiana Limestone (M-NEA)

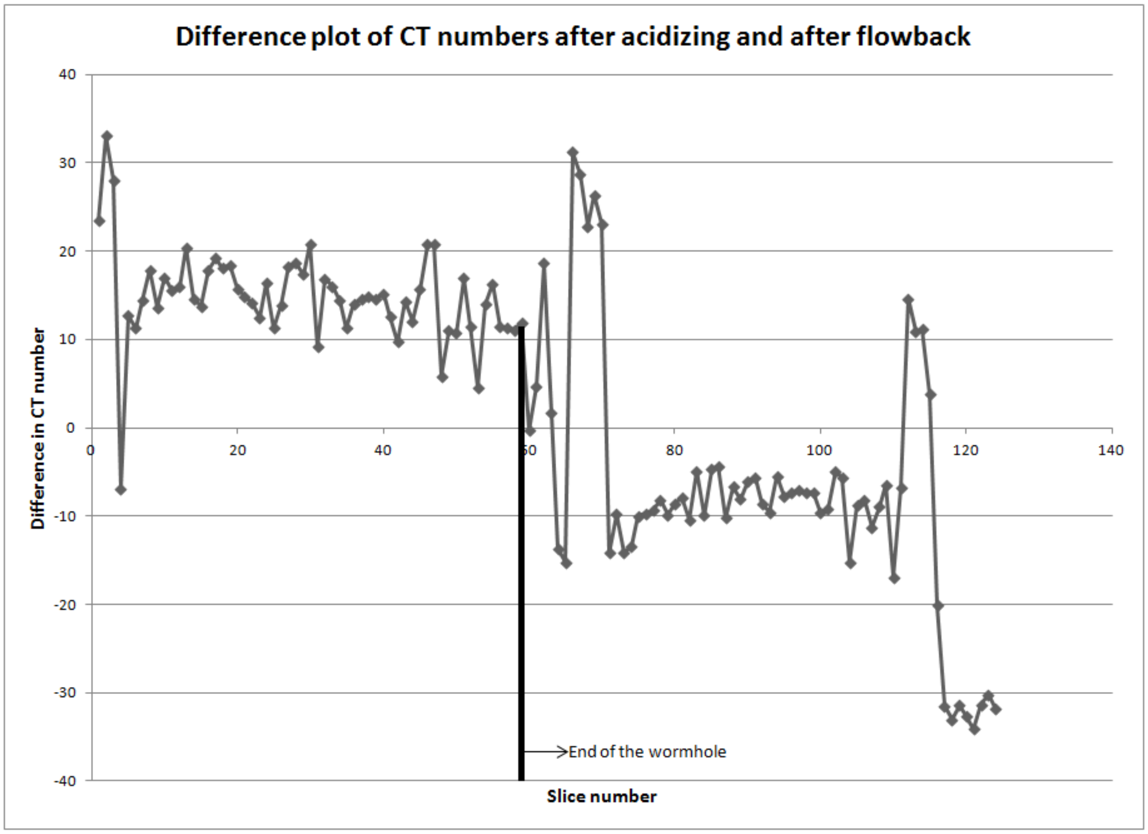

Figure 4.6b Difference plot for Indiana Limestone (M-NEA)

4.1.1.7 Combined Difference Plot

The Combined Difference Plot (Fig 4.7) is a collection of all the Difference Plots, and is centered at the end of the wormhole. 15 data points before and after the end of the wormhole are taken, and are plotted in the same chart to compare the difference in height of the peaks, to form an idea of the efficiency of the spent acid clean-up.

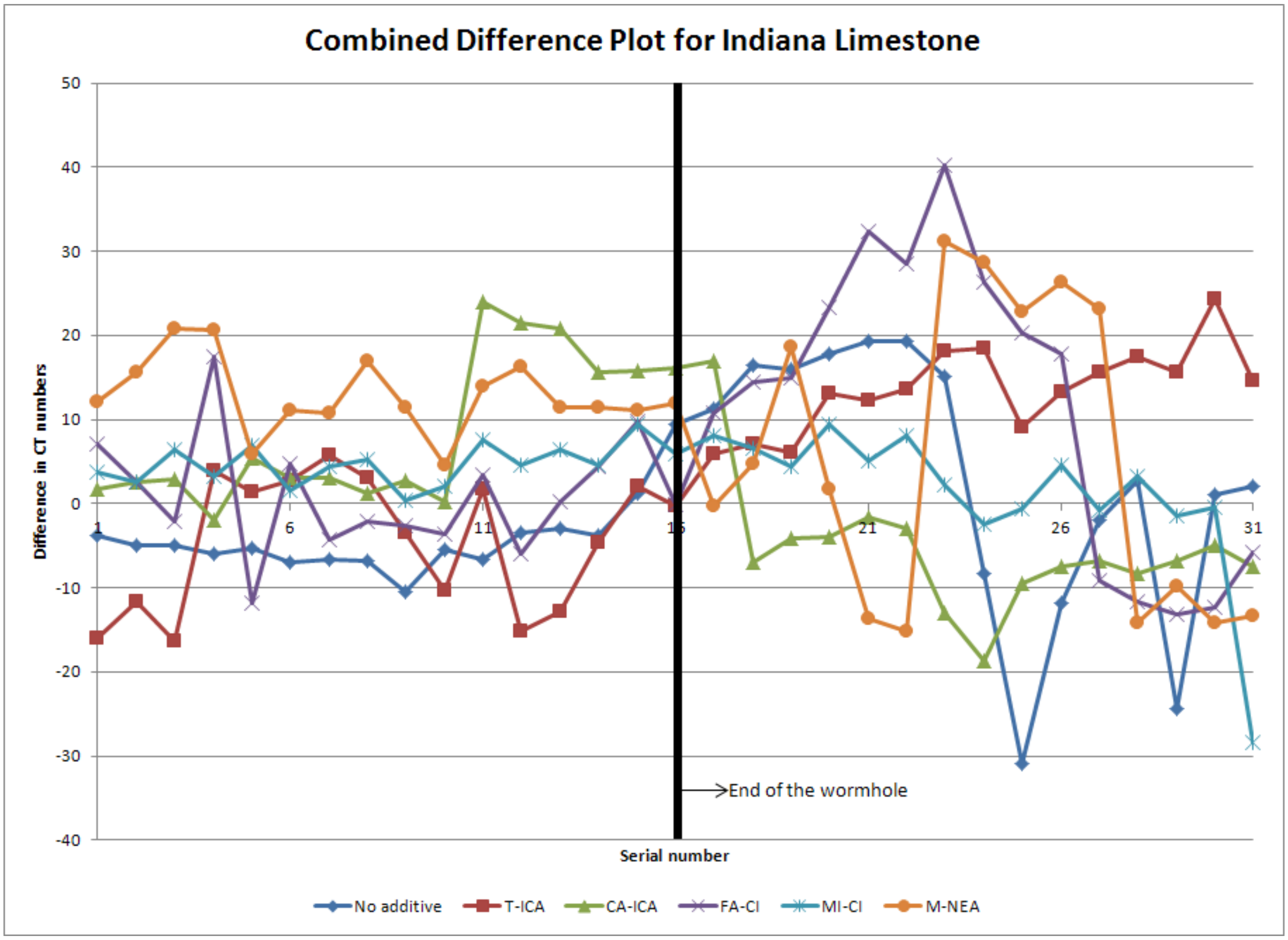

Figure 4.7 Combined Difference plot for Indiana Limestone (all additives)

As seen from the chart, the additives according to the peak height (highest peak to lowest) are listed below:

1. FA-CI
2. M-NEA
3. T-ICA
4. CA-ICA
5. No additive
6. MI-CI

The plot shows that for all the additives, the spent acid clean-up was comparable to the control i.e. no additive case. However, the change in CT number range is too small to call which additive performed the best in terms of spent acid clean-up, or the worst.

4.1.2 Texas Cream Chalk

Similar to Indiana Limestone, six experiments were performed in total with Texas Cream Chalk cores. One experiment was done without any additive to serve as a control. The results are as under:

4.1.2.1 No additive

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.8a, 4.8b and 4.8c):

TABLE 4.8a-ACID FLOW PARAMETERS (TEXAS CREAM CHALK; NO ADDITIVE)

1	Acid Injection Rate	8	cc/min
2	Injection time	10	min

TABLE 4.8b-ACID FORMULATION (TEXAS CREAM CHALK; NO ADDITIVE)

1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g

TABLE 4.8c-FLOWBACK PARAMETERS (TEXAS CREAM CHALK; NO ADDITIVE)

1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	1000	psi
4	Pr. drop across the core	713	psi
5	Flowrate	3.3	L/min
6	Flow time	27	min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.8a) can be seen below. Similar to the Indiana Limestone plots seen earlier, the recession of the spent acid front is visible in the area marked “Region of interest”. The end of the wormhole is also mentioned in the plot.

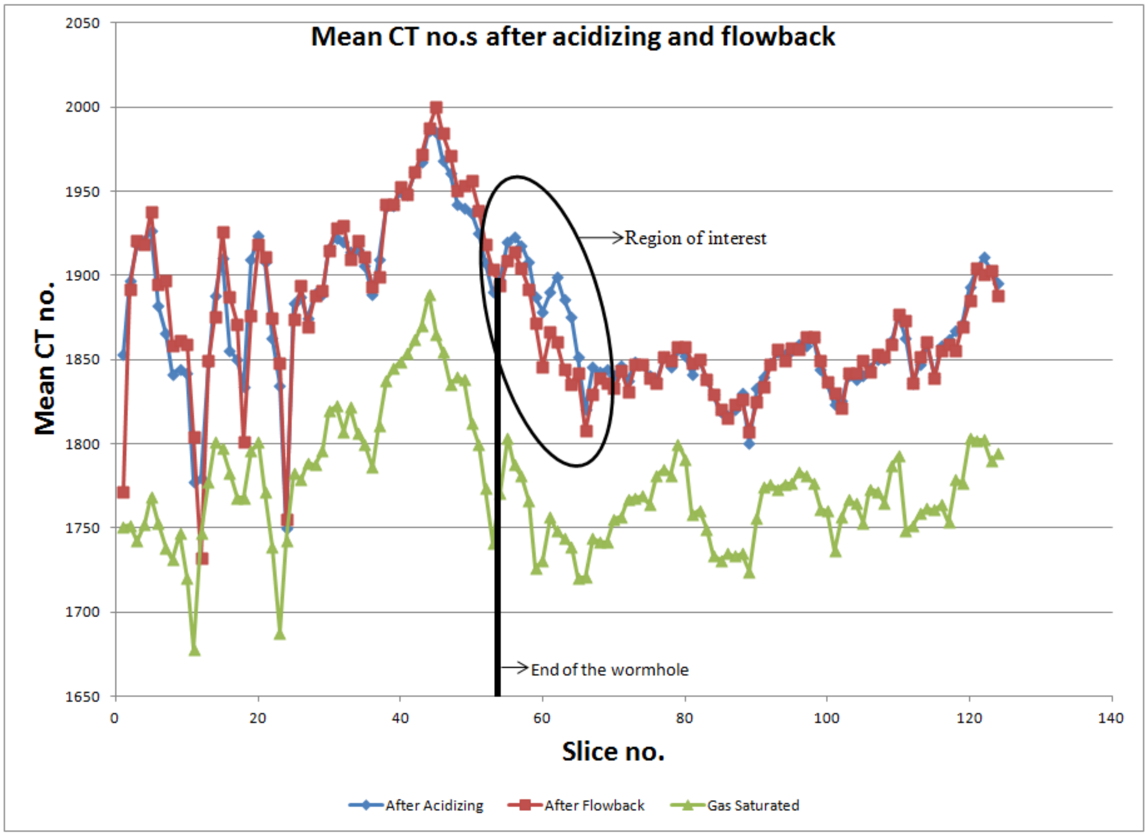

Figure 4.8a Mean CT number plot for Texas Cream Chalk (no additive)

The Difference plot (Fig 4.8b) plots the difference in CT numbers after acidizing and after flowback. Positive peak shows the recession of the spent acid front with the magnitude of the peak corresponding to how much of the spent acid has been produced during flowback.

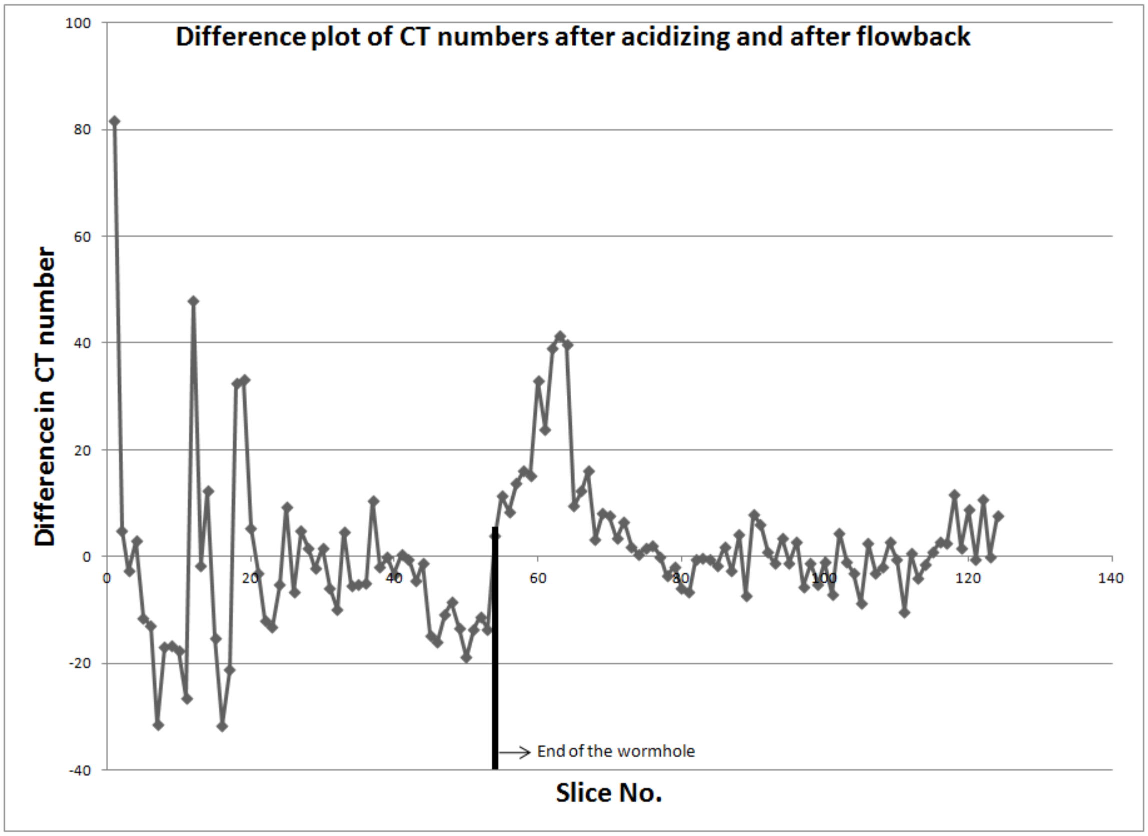

Figure 4.8b Difference plot for Texas Cream Chalk (no additive)

4.1.2.2 T-ICA

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.9a, 4.9b and 4.9c):

TABLE4.9a-ACID FLOW PARRAMETERS (TEXAS CREAM CHALK; T-ICA)

1	Gas Permeability	3.5	md
2	Acid Injection Rate	8	cc/min
2	Injection time	9	min

TABLE 4.9b-ACID FORMULATION (TEXAS CREAM CHALK; T-ICA)

1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	T-ICA (2 wt%)	6.3	g

TABLE 4.9c-FLOWBACK PARAMETERS (TEXAS CREAM CHALK; T-ICA)

1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	800	psi
4	Pr. drop across the core	435	psi
5	Flowrate	6.5	L/min
6	Flow time	120	min
7	Flow meter zero error	0.5	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.9a) and the Difference plot (Fig 4.9b) are seen below.

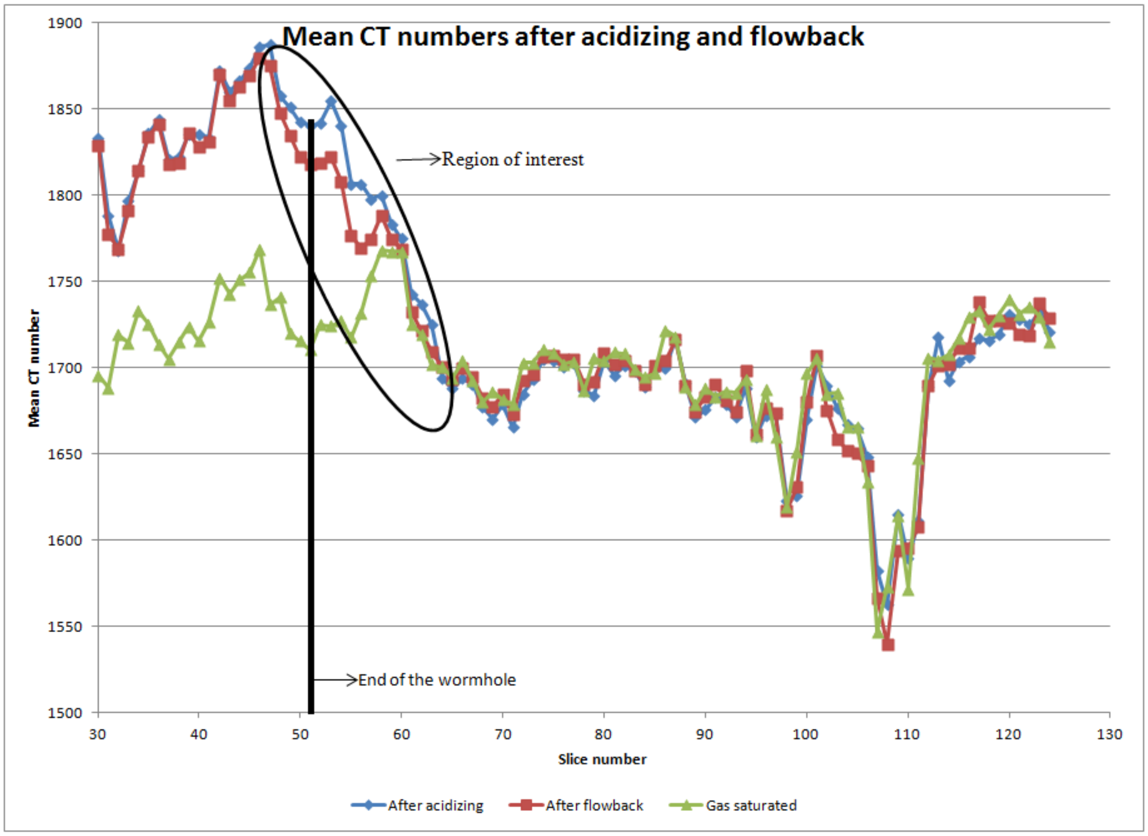

Figure 4.9a Mean CT number plot for Texas Cream Chalk (T-ICA)

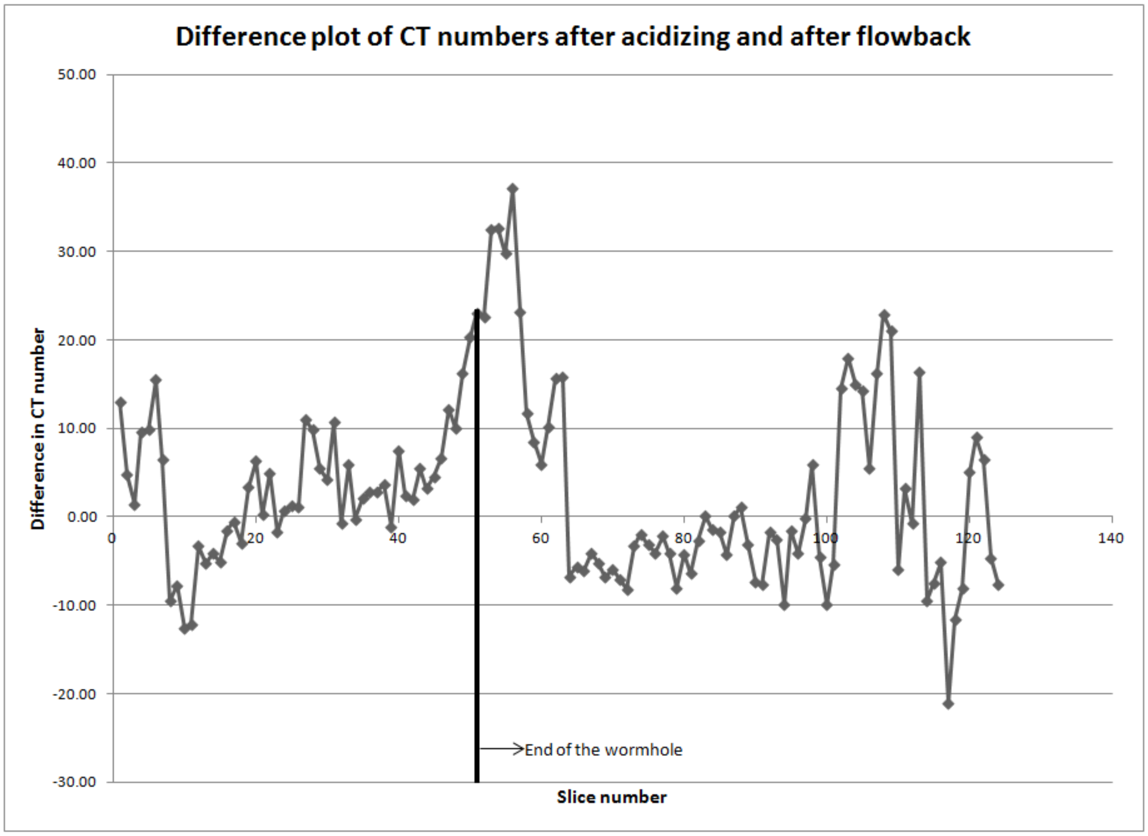

Figure 4.9b Difference plot for Texas Cream Chalk (T-ICA)

4.1.2.3 CA-ICA

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.10a, 4.10b and 4.10c):

TABLE 4.10a-ACID FLOW PARAMETERS (TEXAS CREAM CHALK; CA-ICA)

1	Acid Injection Rate	8	cc/min		
2	Injection time	10	min	40	sec

TABLE 4.10b-ACID FORMULATION (TEXAS CREAM CHALK; CA-ICA)

1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	ICA Ferrotrol-300L (2 wt%)	6.3	g

TABLE 4.10c-FLOWBACK PARAMETERS (TEXAS CREAM CHALK; CA-ICA)

1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	800	psi
4	Pr. drop across the core	460	psi
5	Flowrate	3.6	L/min
6	Flow time	120	min
7	Flow meter zero error	0.5	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.10a) and the Difference plot (Fig 4.10b) are seen below.

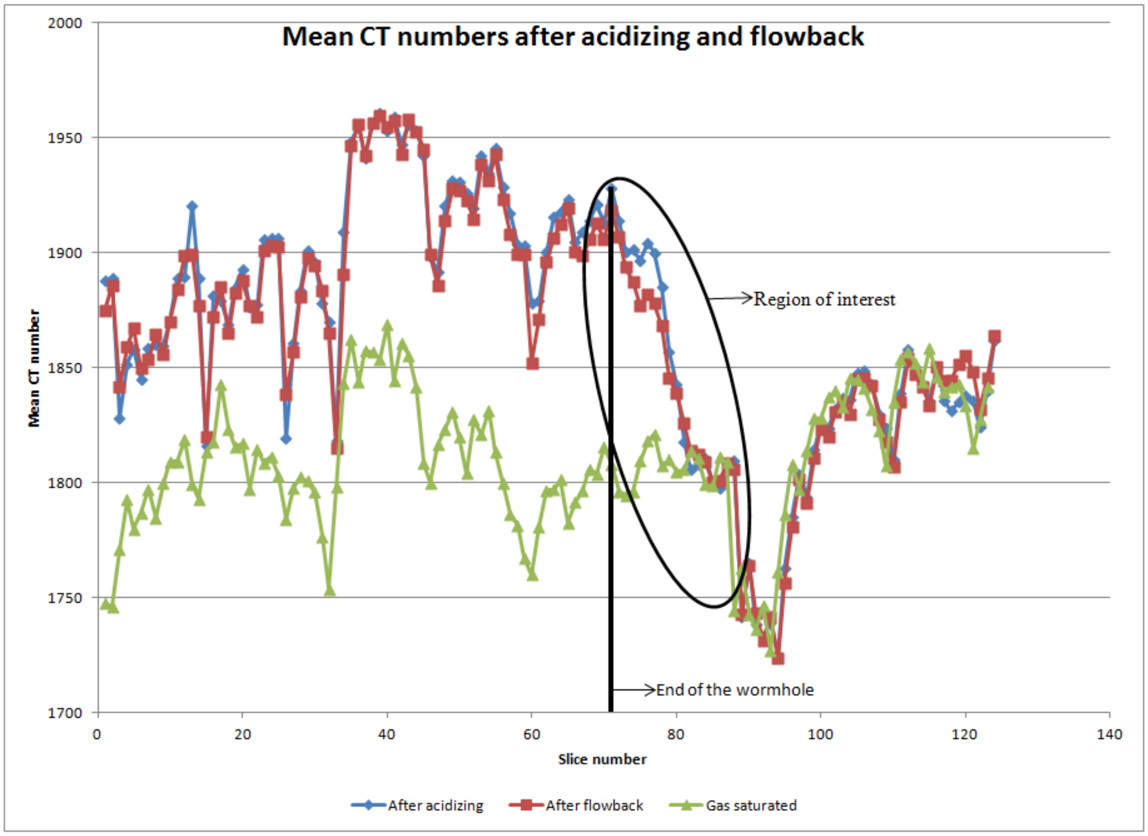

Figure 4.10a Mean CT number plot for Texas Cream Chalk (CA-ICA)

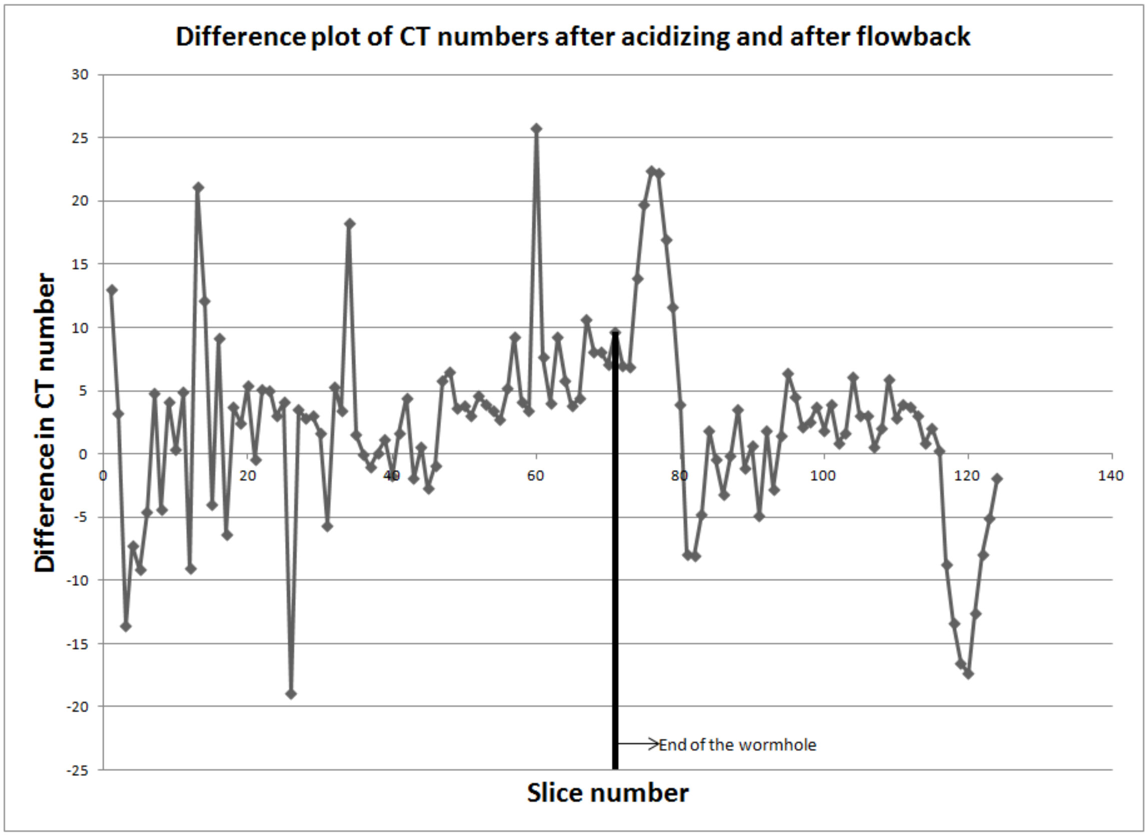

Figure 4.10b Difference plot for Texas Cream Chalk (CA-ICA)

4.1.2.4 FA-CI

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.11a, 4.11b and 4.11c):

TABLE 4.11a-ACID FLOW PARAMETERS (TEXAS CREAM CHALK; FA-CI)

1	Gas Permeability	4	md
2	Acid Injection Rate	8	cc/min
3	Injection time	7	min

TABLE 4.11b-ACID FORMULATION (TEXAS CREAM CHALK; FA-CI)

1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	FA-CI (2 wt%)	6.3	g

TABLE 4.11c-FLOWBACK PARAMETERS (TEXAS CREAM CHALK; FA-CI)

1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	800	psi
4	Pr. drop across the core	458	psi
5	Flowrate	3.5	L/min
6	Flow time	120	min
7	Flow meter zero error	0.5	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.11a) and the Difference plot (Fig 4.11b) are seen below.

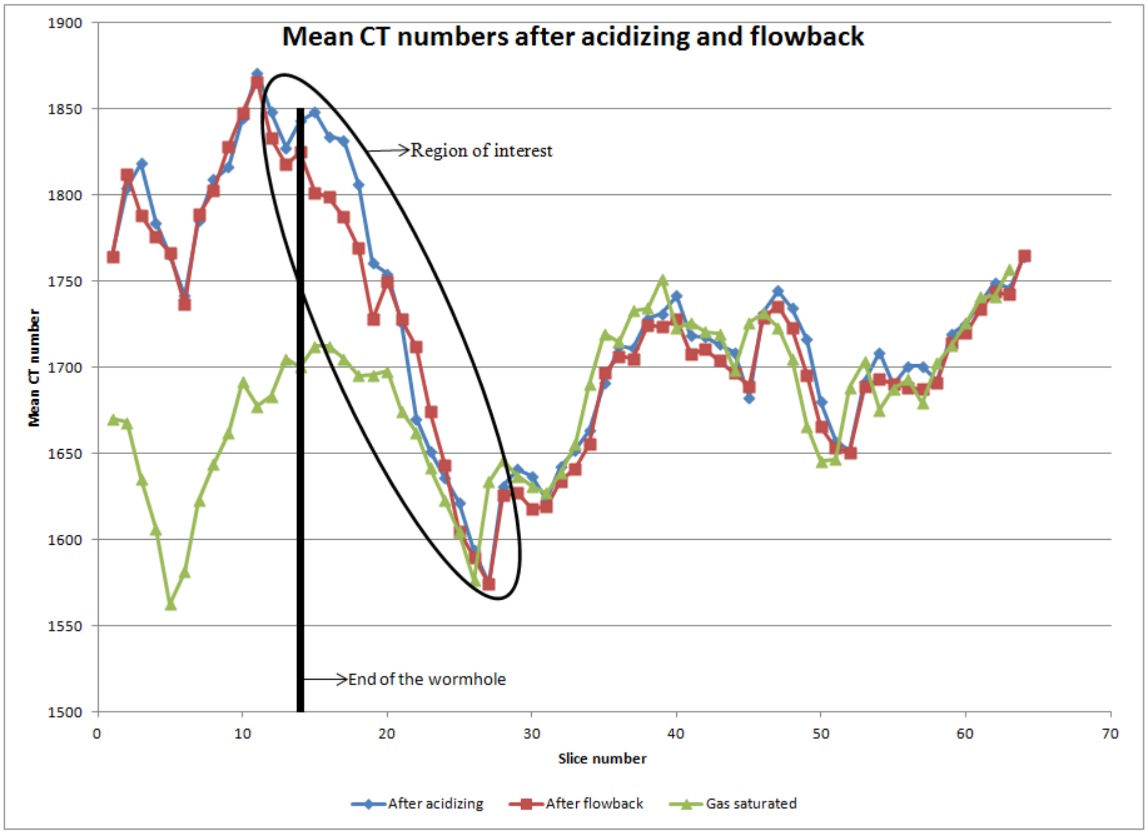

Figure 4.11a Mean CT number plot for Texas Cream Chalk (FA-CI)

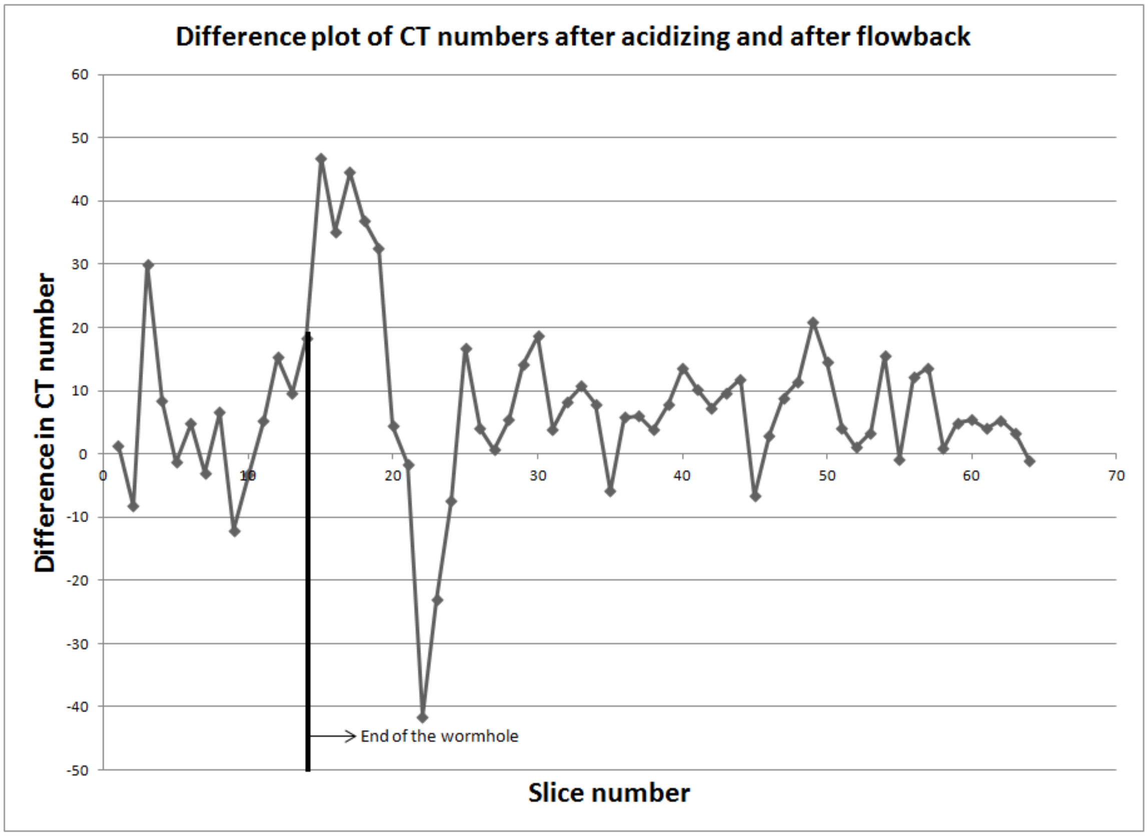

Figure 4.11b Difference plot for Texas Cream Chalk (FA-CI)

4.1.2.5 MI-CI

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.12a, 4.12b and 4.12c):

TABLE 4.12a-ACID FLOW PARAMETERS (TEXAS CREAM CHALK; MI-CI)					
1	Gas Permeability	5.3	md		
2	Acid Injection Rate	8	cc/min		
3	Injection time	5	min	40	sec

TABLE 4.12b-ACID FORMULATION (TEXAS CREAM CHALK; MI-CI)			
1	Water	94.5	cc
2	HCl (15 wt%)	55.5	cc
3	NaI (5 wt%)	7.9	g
4	MI-CI (2 wt%)	3.2	g

TABLE 4.12c-FLOWBACK PARAMETERS (TEXAS CREAM CHALK; MI-CI)			
1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	800	psi
4	Pr. drop across the core	455	psi
5	Flowrate	9.2	L/min
6	Flow time	126	min
7	Flow meter zero error	0.4	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.12a) and the Difference plot (Fig 4.12b) are seen below.

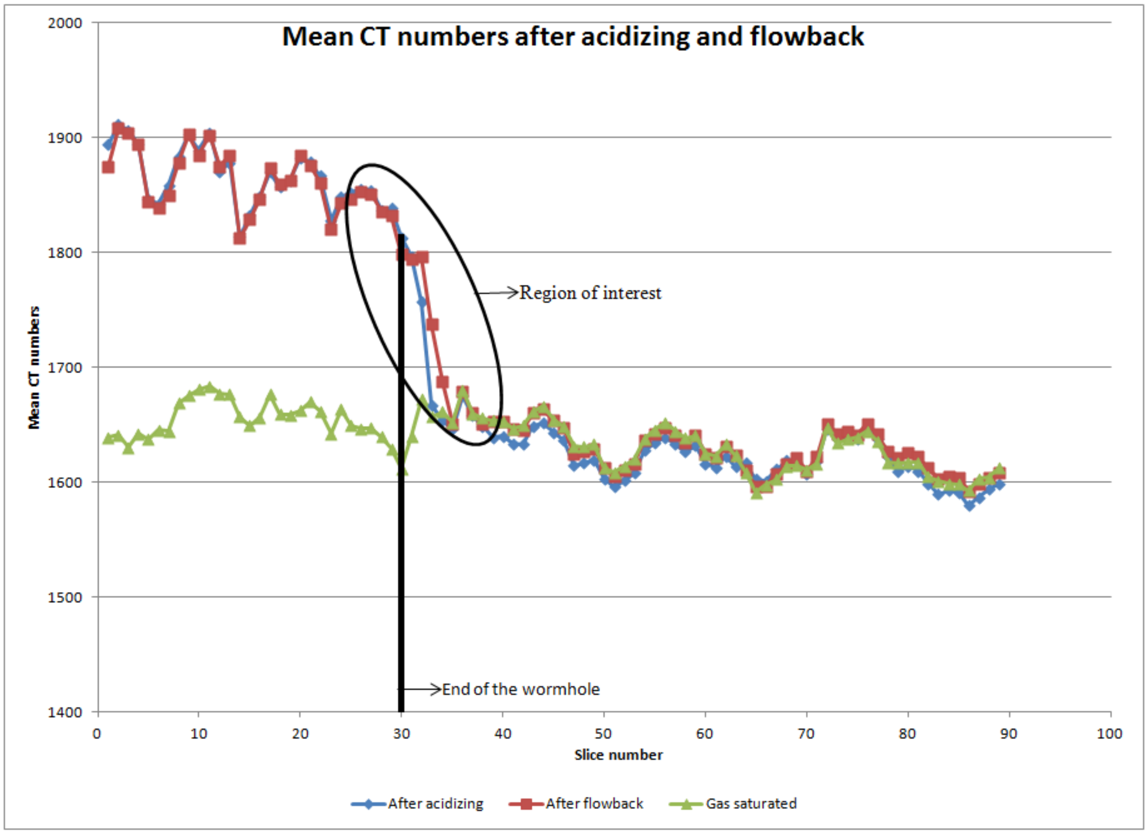

Figure 4.12a Mean CT number plot for Texas Cream Chalk (MI-CI)

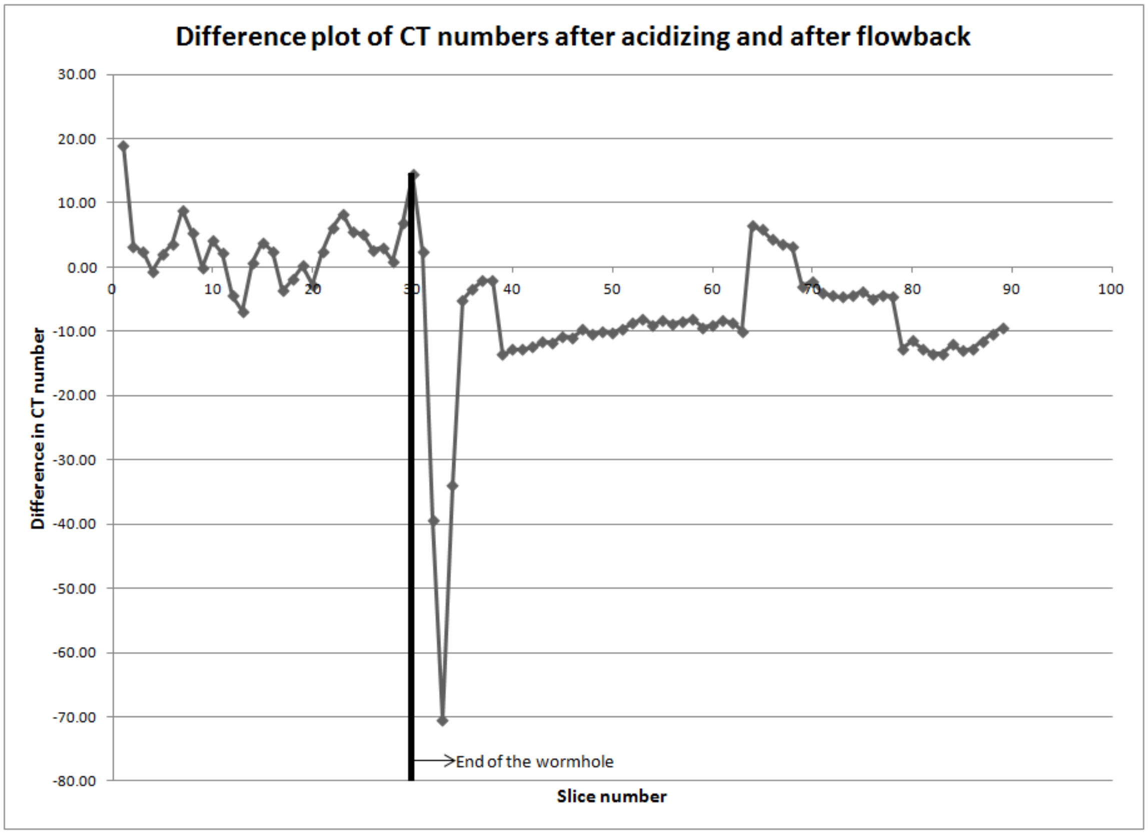

Figure 4.12b Difference plot for Texas Cream Chalk (MI-CI)

The negative peak in the Difference plot shows that the spent acid clean-up was not effective for the Corrosion Inhibitor MI-CI.

4.1.2.6 M-NEA

For the experiment, the acidizing and flowback parameters are as follows (see Tables 4.13a, 4.13b and 4.13c):

TABLE 4.13a-ACID FLOW PARAMETERS (TEXAS CREAM CHALK; M-NEA)			
1	Gas Permeability	3.2	md
2	Acid Injection Rate	8	cc/min
3	Injection time	10	min

TABLE 4.13b-ACID FORMULATION (TEXAS CREAM CHALK; M-NEA)			
1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	M-NEA (2 wt%)	6.3	g

TABLE 4.13c-FLOWBACK PARAMETERS (TEXAS CREAM CHALK; M-NEA)			
1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	500	psi
4	Pr. drop across the core	176	psi
5	Flowrate	11.4	L/min
6	Flow time	120	min
7	Flow meter zero error	0.4	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.13a) and the Difference plot (Fig 4.13b) are seen below.

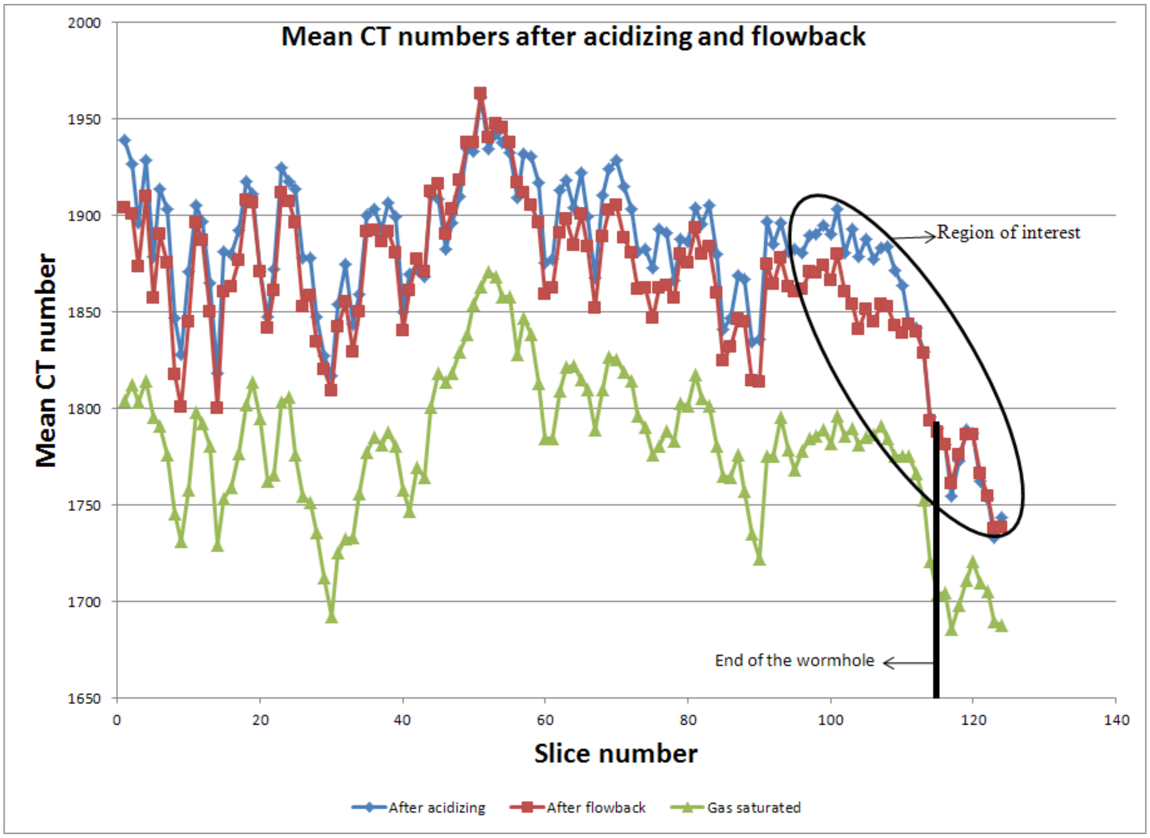

Figure 4.13a Mean CT number plot for Texas Cream Chalk (M-NEA)

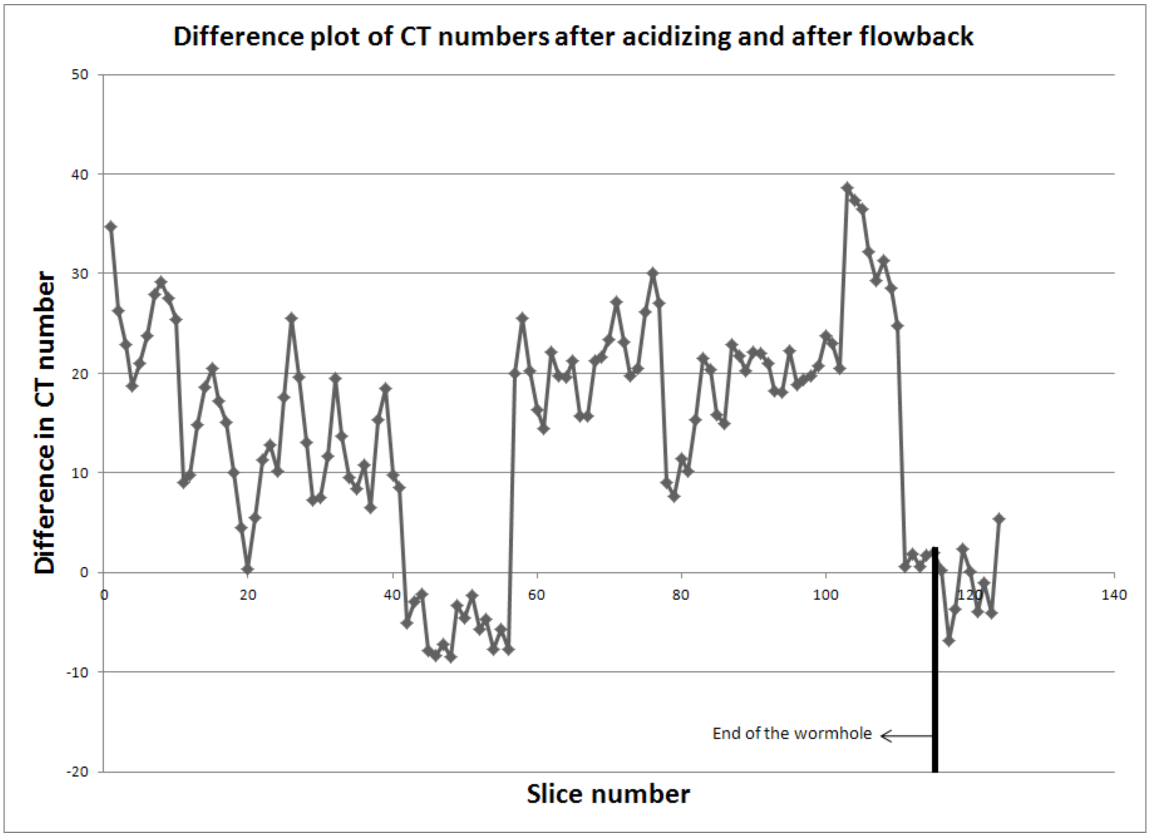

Figure 4.13b Difference plot for Texas Cream Chalk (M-NEA)

The results shown above were not deemed conclusive because the wormhole ended very close to the outlet face of the core. Moreover, the CT scan after flowback couldn't be performed immediately after gas flowback, and was performed 3 days later. Hence the experiment was repeated, even though it showed a decrease in CT numbers after flowback (seen just before the end of the wormhole).

For the second experiment, the acidizing and flowback parameters are as follows (see Tables 4.13d, 4.13e and 4.13f):

TABLE 4.13d-ACID FLOW PARAMETERS (TEXAS CREAM CHALK; M-NEA; 2nd EXPERIMENT)					
1	Gas Permeability	7.3	md		
2	Acid Injection Rate	8	cc/min		
3	Injection time	5	min	29	sec

TABLE 4.13d-ACID FORMULATION (TEXAS CREAM CHALK; M-NEA; 2nd EXPERIMENT)			
1	Water	189	cc
2	HCl (15 wt%)	111	cc
3	NaI (5 wt%)	15.8	g
4	M-NEA (2 wt%)	6.3	g

TABLE 4.13f-FLOWBACK PARAMETERS (TEXAS CREAM CHALK; M-NEA; 2nd EXPERIMENT)			
1	Back pressure	300	psi
2	Overburden pressure	1500	psi
3	Inlet pr.	800	psi
4	Pr. drop across the core	456	psi
5	Flowrate	9.0	L/min
6	Flow time	120	min
7	Flow meter zero error	0.5	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.13c) and the Difference plot (Fig 4.13d) are seen below.

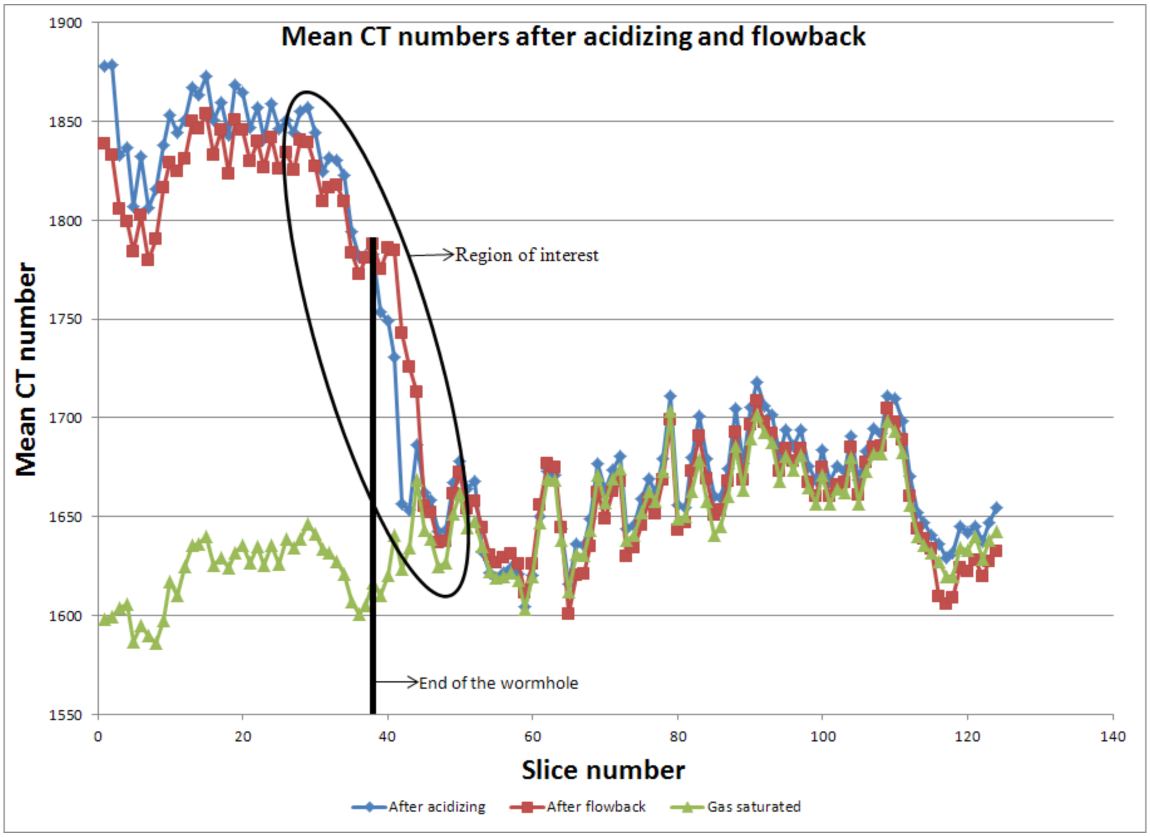

Figure 4.13c Mean CT number plot for Texas Cream Chalk (M-NEA); 2nd experiment

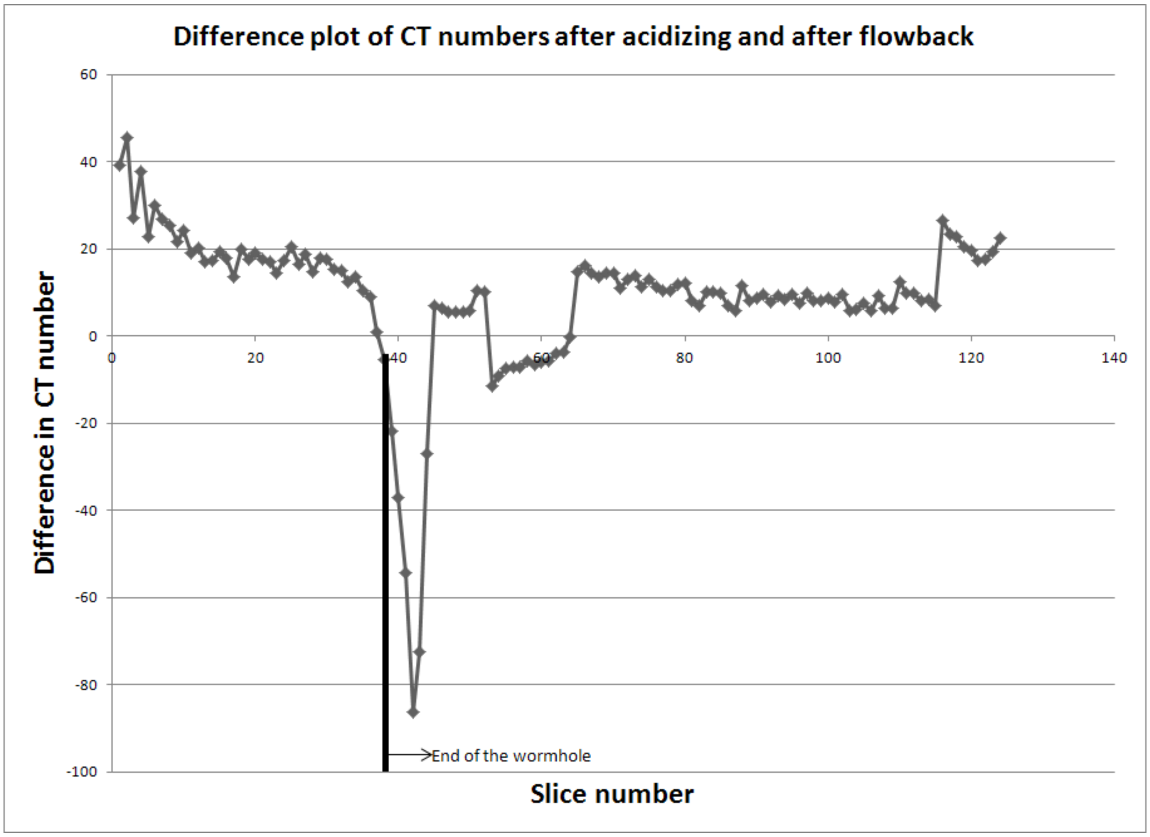

Figure 4.13d Difference plot for Texas Cream Chalk (M-NEA); 2nd experiment

The negative peak in the Difference plot shows that the spent acid clean-up was not effective for the non-emulsifying agent. This result was unexpected; hence it was repeated for a third time.

For the third experiment, the acidizing and flowback parameters are as follows (see Tables 4.13g, 4.13h and 4.13i):

TABLE 4.13g-ACID FLOW PARAMETERS (TEXAS CREAM CHALK; M-NEA; 3rd EXPERIMENT)					
1	Gas Permeability	4.4	md		
2	Acid Injection Rate	8	cc/min		
3	Injection time	5	min	30	sec

TABLE 4.13h-ACID FORMULATION (TEXAS CREAM CHALK; M-NEA; 3rd EXPERIMENT)			
1	Water	94.5	cc
2	HCl (15 wt%)	55.5	cc
3	NaI (5 wt%)	7.9	g
4	M-NEA (2 wt%)	3.2	g

TABLE 4.13i-FLOWBACK PARAMETERS (TEXAS CREAM CHALK; M-NEA; 3rd EXPERIMENT)			
1	Back pressure	300	Psi
2	Overburden pressure	1500	Psi
3	Inlet pr.	800	Psi
4	Pr. drop across the core	463	Psi
5	Flowrate	8.7	L/min
6	Flow time	120	Min
7	Flow meter zero error	0.4	L/min

The plot of mean CT numbers after acidizing and after flowback (Fig 4.13e) and the Difference plot (Fig 4.13f) are seen below.

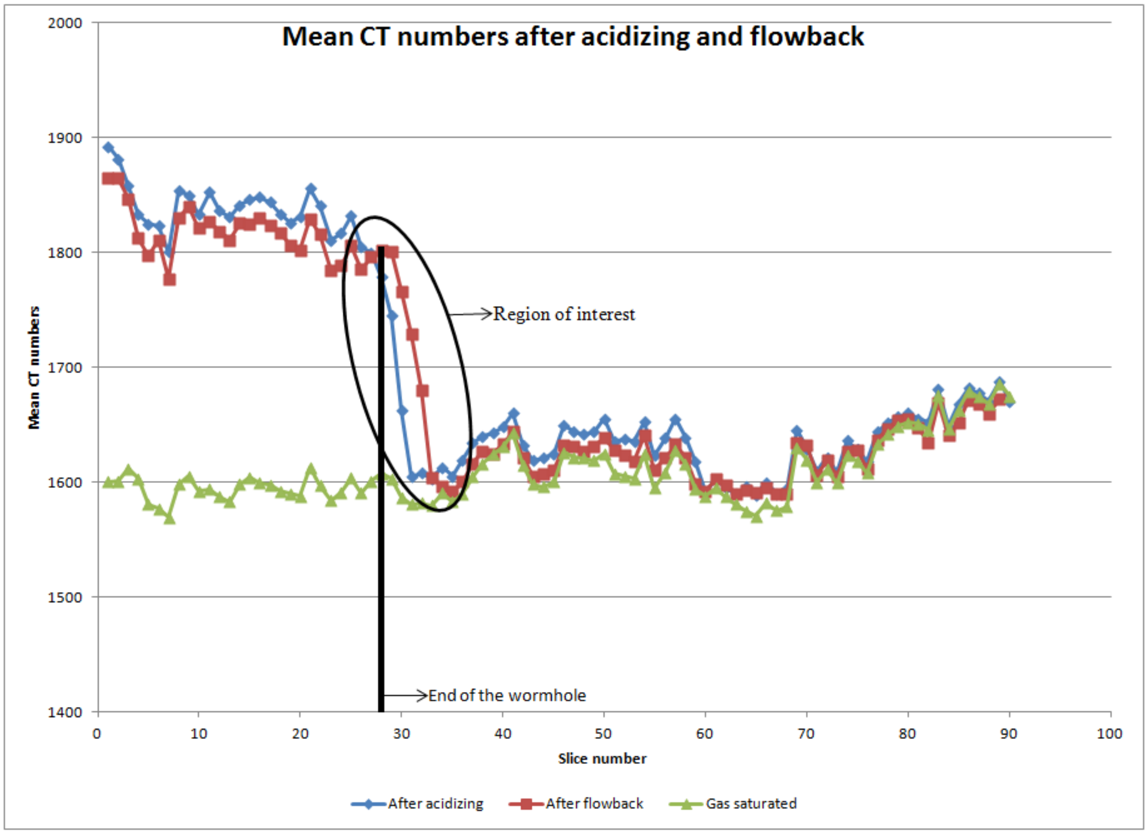

Figure 4.13e Mean CT number plot for Texas Cream Chalk (M-NEA); 3rd experiment

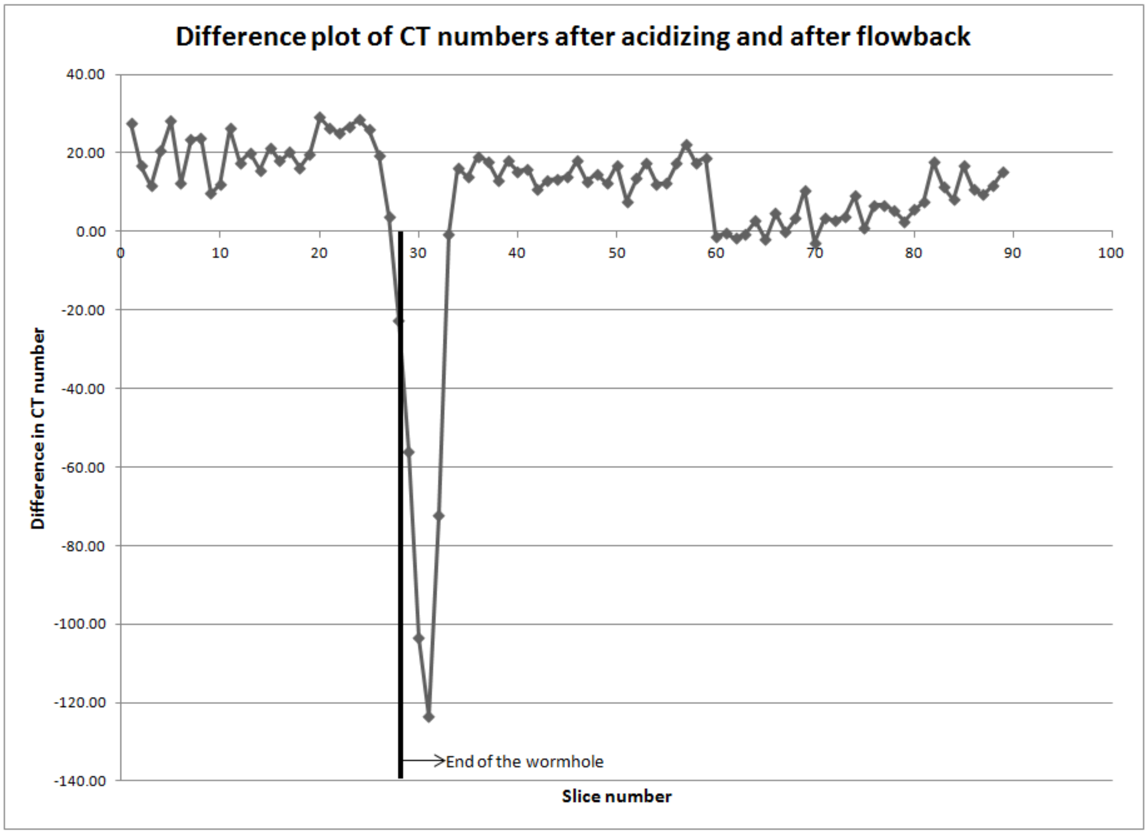

Figure 4.13f Difference plot for Texas Cream Chalk (M-NEA); 3rd experiment

Quite like the previous result, the spent acid clean-up wasn't effective for this case. It can be observed that the spent acid has permeated deeper into the core. Hence this result was finally deemed to be conclusive.

4.1.2.7 Combined Difference Plot

Similar to the Indiana Limestone, we can see the Combined Difference Plot for Texas Cream Chalk below (Fig 4.14). The additives according to the peak height (highest peak to lowest) are listed below:

1. FA-CI
2. No additive
3. T-ICA
4. CA-ICA
5. MI-CI
6. M-NEA

The Combined Difference Plot for Texas Cream Chalk can be seen below. For M-NEA, the last (or the 3rd experiment) result was used.

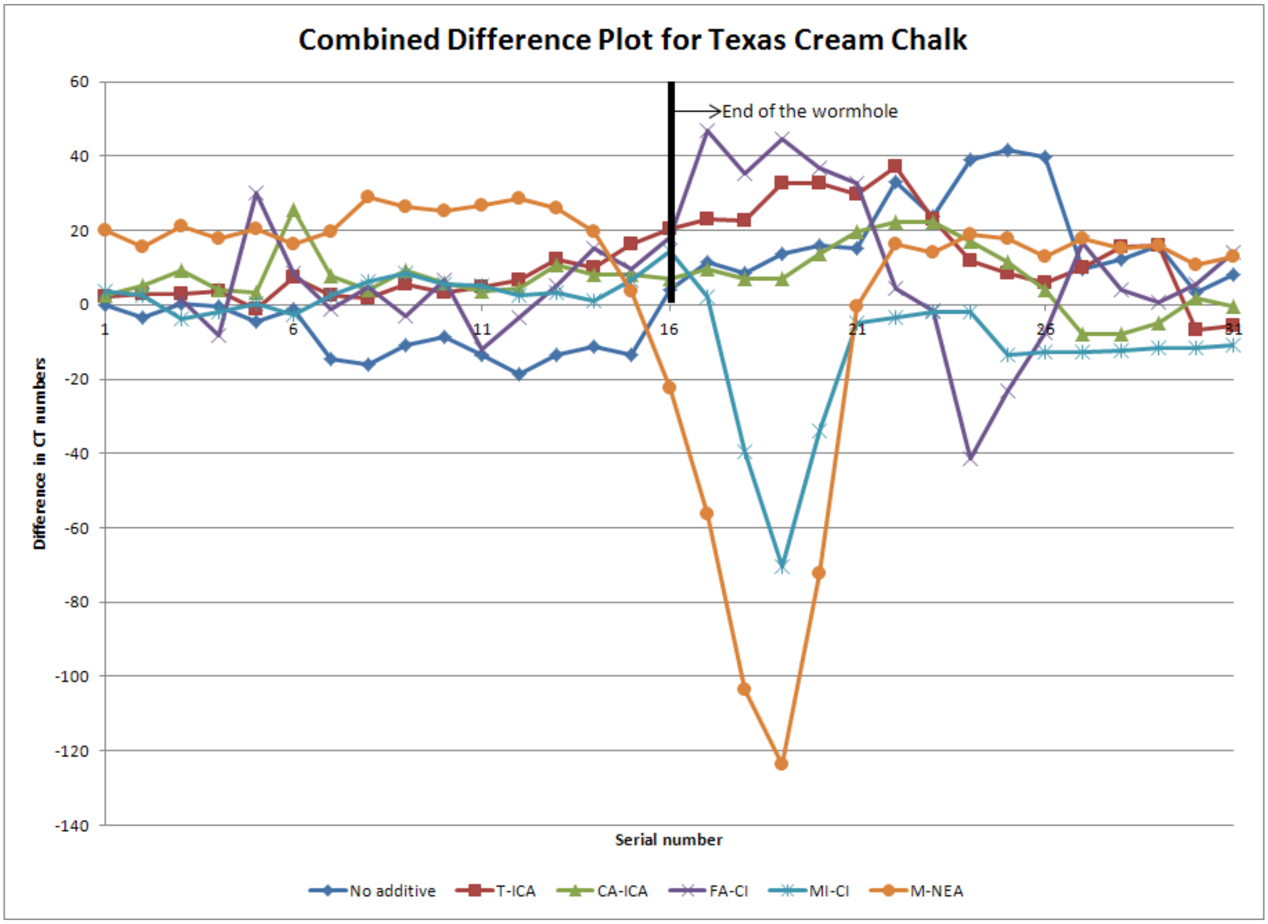

Figure 4.14 **Combined Difference Plot for Texas Cream Chalk (all additives)**

The plot shows that for FA-CI, CA-ICA and T-ICA, the spent acid clean-up was comparable to the control i.e. no additive case. The worst clean-up was found when MI-CI and M-NEA were used.

5. CONCLUSIONS AND RECOMMENDATIONS

1) For Indiana Limestone, the best clean-up was achieved for FA-CI and the worst for MI-CI. But the difference in their mean CT numbers after flowback is only approximately 30, which is too small to declare any additive an outright winner in terms of spent acid clean-up.

2) For Texas Cream Chalk, the best clean-up was achieved for FA-CI and the worst for M-NEA. Moreover, when MI-CI and M-NEA were added to the acid, the spent acid clean-up was found to be inefficient, with the acid front readjusting itself and the spent acid concentration gradient flattening out (as can be seen in the mean CT numbers plot).

3) For M-NEA and MI-CI, it does not mean that the spent acid will not clean up all the time. But more often than not, its clean-up will be hindered by the aforementioned additives, as the experiments have shown. (For M-NEA with Texas Cream Chalk, the spent acid front was found to have been cleaned up on one instance, but upon repetition of the experiment twice, the result couldn’t be replicated.) Moreover, it takes at least 30 minutes from the end of an experiment to perform the subsequent CT scan (with a number of tasks performed in between such as depressurizing the

equipment or pre-heating the CT scanner). This is ample time for the spent acid front to imbibe deeper into the core, and give a negative peak on the difference plot.

4) FA-CI was found to perform the best in terms of reduction in CT numbers after flowback (i.e. spent acid clean-up) for both Indiana Limestone and Texas Cream Chalk.

5) This series of experiments should be repeated for water or brine saturated cores (instead of gas saturated) to have a condition similar to actual conditions.

6) Moreover, the experiments should be conducted with an aluminum coreholder so as to scan the acidized core without taking it out of the coreholder and disturbing or contaminating it.

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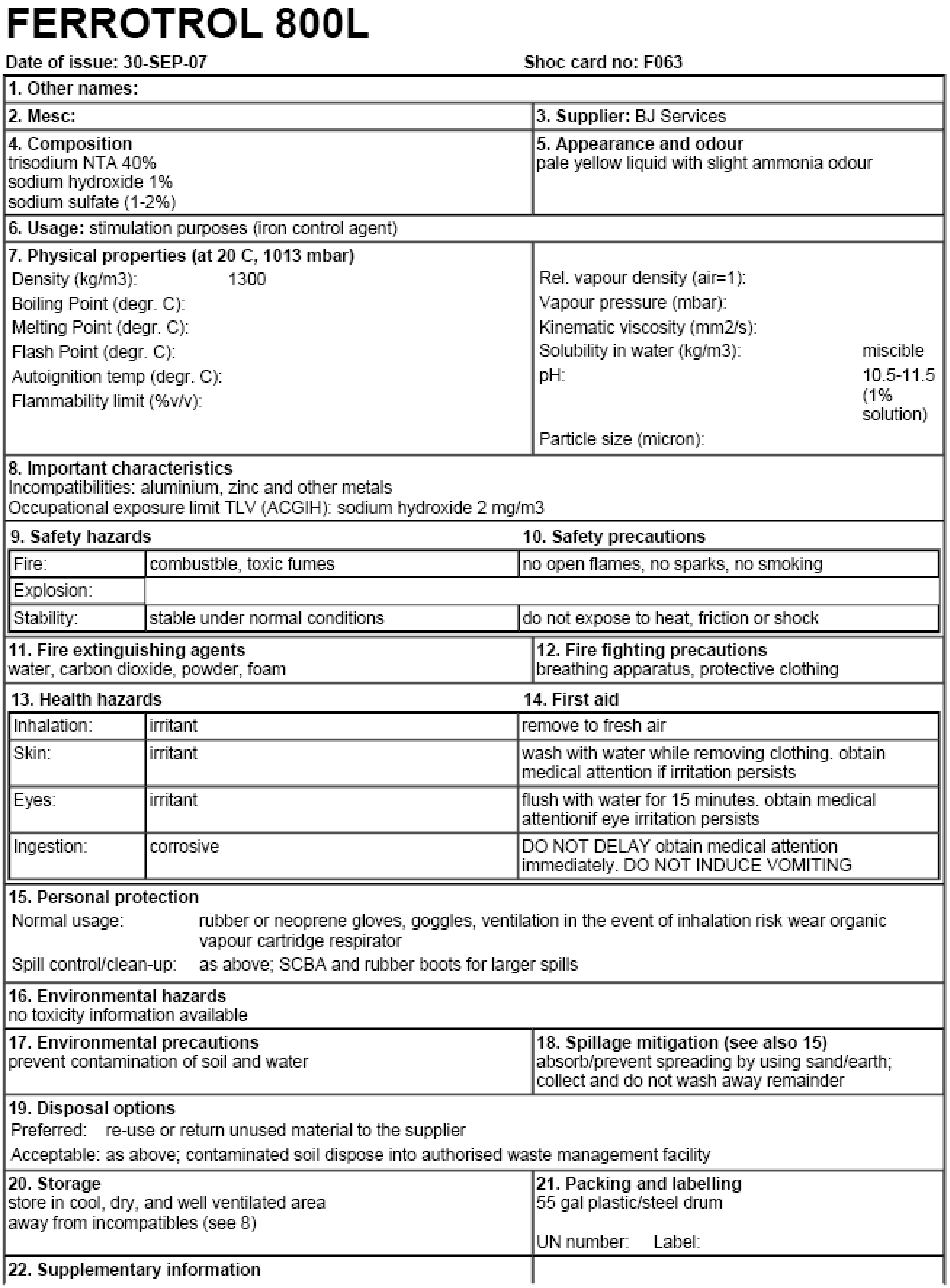
APPENDIX A

MSDSs of the Additives Used

A-1 T-ICA MSDS



FERROTROL 800L

Date of issue: 30-SEP-07 **Shoc card no: F063**

1. Other names:

2. Mesc:	**3. Supplier:** BJ Services
4. Composition trisodium NTA 40% sodium hydroxide 1% sodium sulfate (1-2%)	**5. Appearance and odour** pale yellow liquid with slight ammonia odour

6. Usage: stimulation purposes (iron control agent)

7. Physical properties (at 20 C, 1013 mbar)

Density (kg/m3):	1300	Rel. vapour density (air=1):	
Boiling Point (degr. C):		Vapour pressure (mbar):	
Melting Point (degr. C):		Kinematic viscosity (mm2/s):	
Flash Point (degr. C):		Solubility in water (kg/m3):	miscible
Autoignition temp (degr. C):		pH:	10.5-11.5 (1% solution)
Flammability limit (%v/v):			
		Particle size (micron):	

8. Important characteristics
Incompatibilities: aluminium, zinc and other metals
Occupational exposure limit TLV (ACGIH): sodium hydroxide 2 mg/m3

9. Safety hazards		**10. Safety precautions**
Fire:	combustble, toxic fumes	no open flames, no sparks, no smoking
Explosion:		
Stability:	stable under normal conditions	do not expose to heat, friction or shock

11. Fire extinguishing agents water, carbon dioxide, powder, foam	**12. Fire fighting precautions** breathing apparatus, protective clothing

13. Health hazards		**14. First aid**
Inhalation:	irritant	remove to fresh air
Skin:	irritant	wash with water while removing clothing. obtain medical attention if irritation persists
Eyes:	irritant	flush with water for 15 minutes. obtain medical attentionif eye irritation persists
Ingestion:	corrosive	DO NOT DELAY obtain medical attention immediately. DO NOT INDUCE VOMITING

15. Personal protection

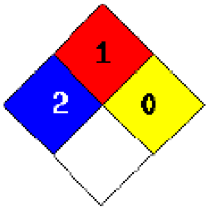
Normal usage:	rubber or neoprene gloves, goggles, ventilation in the event of inhalation risk wear organic vapour cartridge respirator
Spill control/clean-up:	as above; SCBA and rubber boots for larger spills

16. Environmental hazards
no toxicity information available

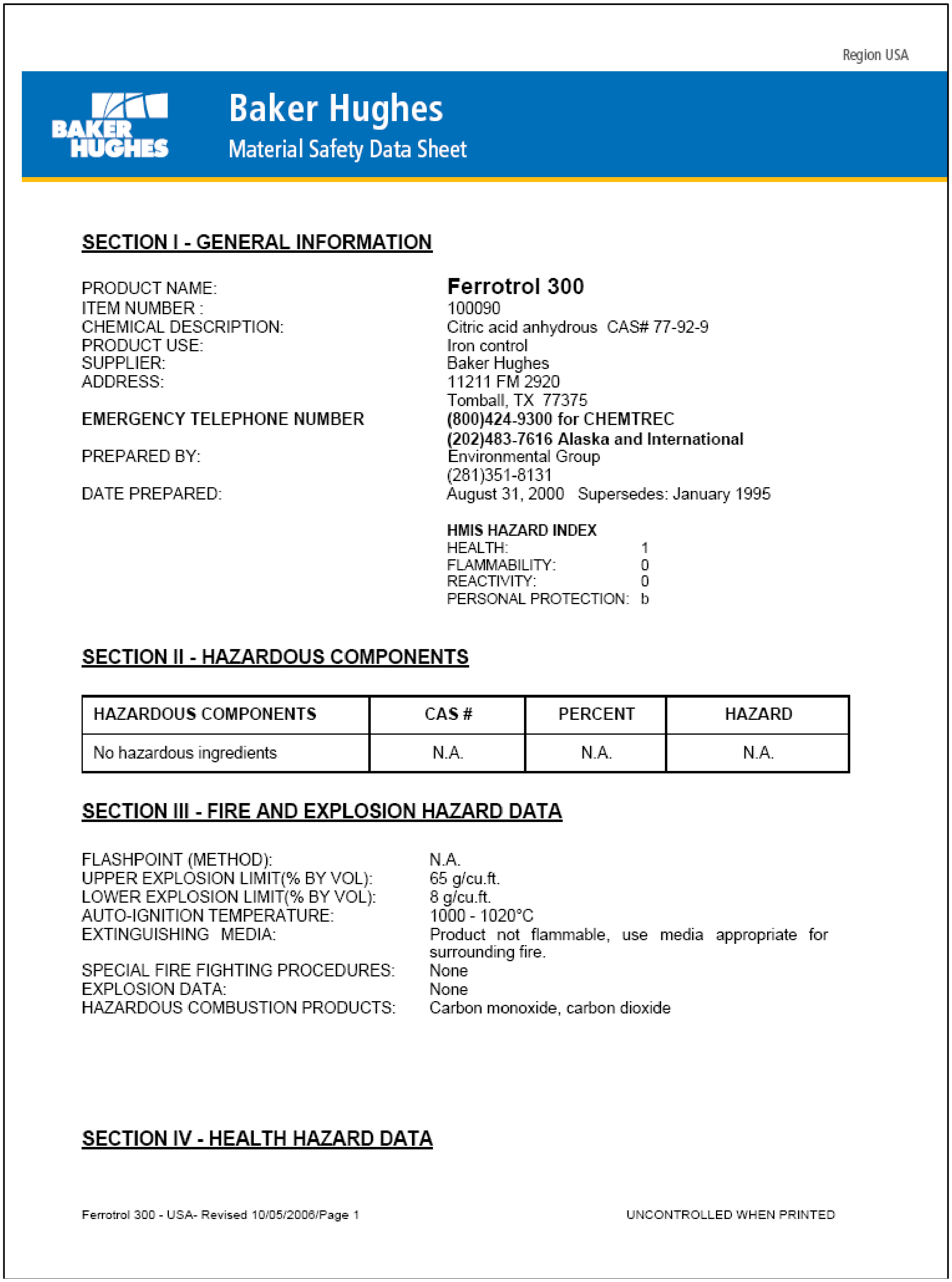
17. Environmental precautions prevent contamination of soil and water	**18. Spillage mitigation (see also 15)** absorb/prevent spreading by using sand/earth; collect and do not wash away remainder

19. Disposal options
Preferred: re-use or return unused material to the supplier
Acceptable: as above; contaminated soil dispose into authorised waste management facility

20. Storage store in cool, dry, and well ventilated area away from incompatibles (see 8)	**21. Packing and labelling** 55 gal plastic/steel drum UN number: Label:
22. Supplementary information	

Health: Safety: readily generates hydrogen gas in contact with aluminium. may slowly generate hydrogen gas in contact withzinc Environment:	

A-2 CA-ICA MSDS



Region USA

Baker Hughes
Material Safety Data Sheet

SECTION I - GENERAL INFORMATION

PRODUCT NAME:	**Ferrotrol 300**
ITEM NUMBER :	100090
CHEMICAL DESCRIPTION:	Citric acid anhydrous CAS# 77-92-9
PRODUCT USE:	Iron control
SUPPLIER:	Baker Hughes
ADDRESS:	11211 FM 2920 Tomball, TX 77375
EMERGENCY TELEPHONE NUMBER	**(800)424-9300 for CHEMTREC** **(202)483-7616 Alaska and International**
PREPARED BY:	Environmental Group (281)351-8131
DATE PREPARED:	August 31, 2000 Supersedes: January 1995

HMIS HAZARD INDEX

HEALTH:	1
FLAMMABILITY:	0
REACTIVITY:	0
PERSONAL PROTECTION:	b

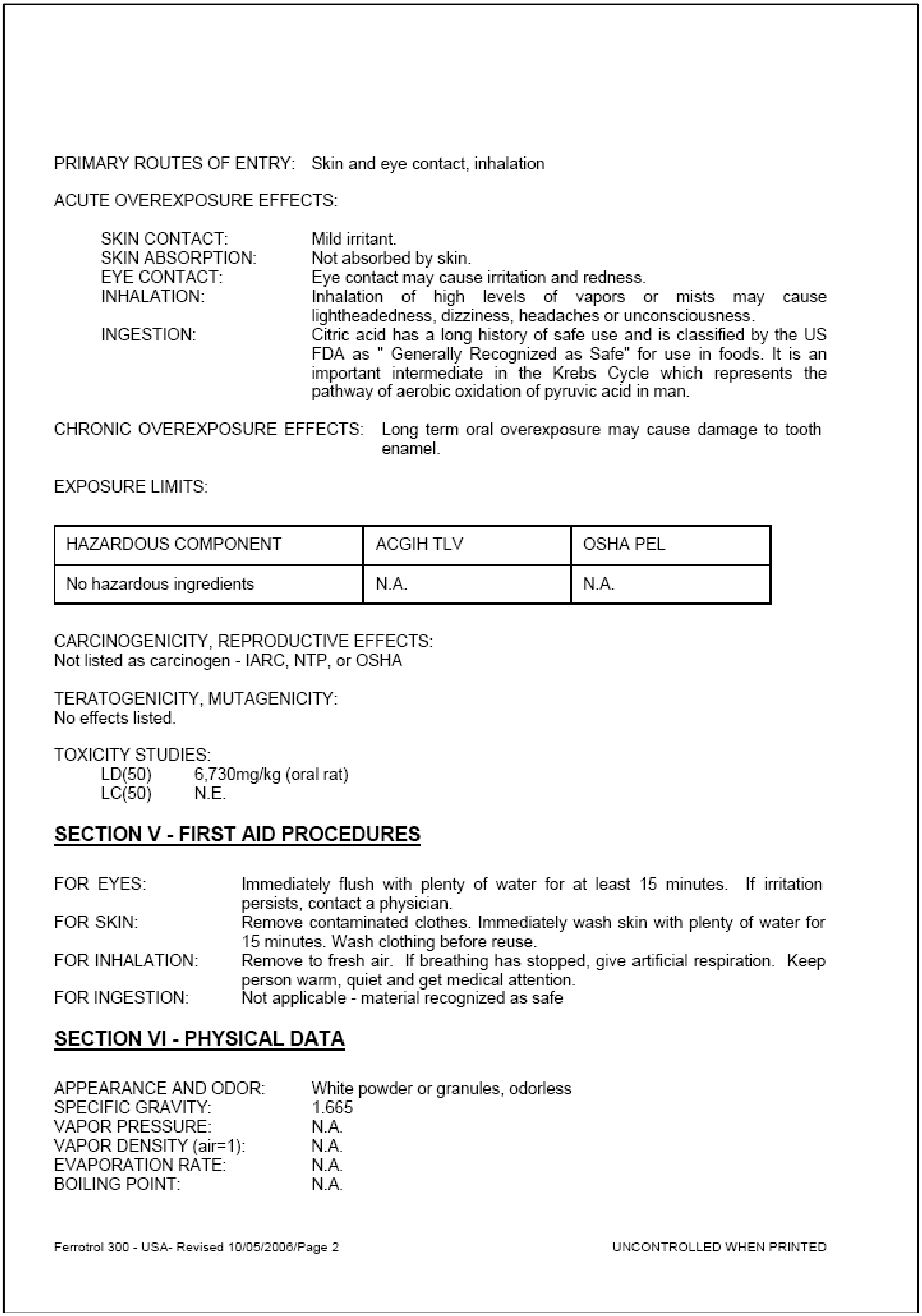
SECTION II - HAZARDOUS COMPONENTS

HAZARDOUS COMPONENTS	CAS #	PERCENT	HAZARD
No hazardous ingredients	N.A.	N.A.	N.A.

SECTION III - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT (METHOD):	N.A.
UPPER EXPLOSION LIMIT(% BY VOL):	65 g/cu.ft.
LOWER EXPLOSION LIMIT(% BY VOL):	8 g/cu.ft.
AUTO-IGNITION TEMPERATURE:	1000 - 1020°C
EXTINGUISHING MEDIA:	Product not flammable, use media appropriate for surrounding fire.
SPECIAL FIRE FIGHTING PROCEDURES:	None
EXPLOSION DATA:	None
HAZARDOUS COMBUSTION PRODUCTS:	Carbon monoxide, carbon dioxide

SECTION IV - HEALTH HAZARD DATA



PRIMARY ROUTES OF ENTRY: Skin and eye contact, inhalation

ACUTE OVEREXPOSURE EFFECTS:

SKIN CONTACT: Mild irritant.
SKIN ABSORPTION: Not absorbed by skin.
EYE CONTACT: Eye contact may cause irritation and redness.
INHALATION: Inhalation of high levels of vapors or mists may cause lightheadedness, dizziness, headaches or unconsciousness.
INGESTION: Citric acid has a long history of safe use and is classified by the US FDA as " Generally Recognized as Safe" for use in foods. It is an important intermediate in the Krebs Cycle which represents the pathway of aerobic oxidation of pyruvic acid in man.

CHRONIC OVEREXPOSURE EFFECTS: Long term oral overexposure may cause damage to tooth enamel.

EXPOSURE LIMITS:

HAZARDOUS COMPONENT	ACGIH TLV	OSHA PEL
No hazardous ingredients	N.A.	N.A.

CARCINOGENICITY, REPRODUCTIVE EFFECTS:
Not listed as carcinogen - IARC, NTP, or OSHA

TERATOGENICITY, MUTAGENICITY:
No effects listed.

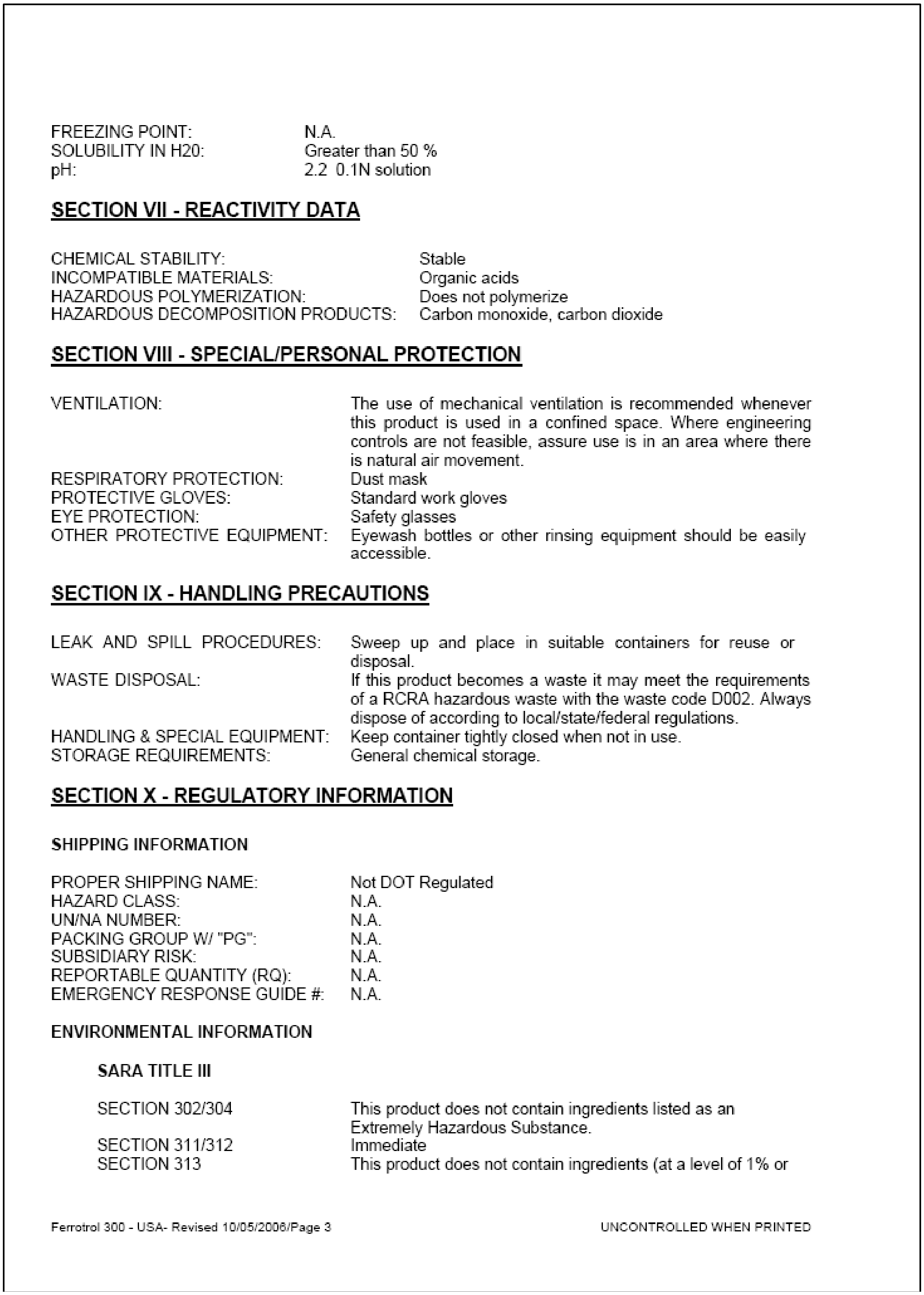
TOXICITY STUDIES:
LD(50) 6,730mg/kg (oral rat)
LC(50) N.E.

SECTION V - FIRST AID PROCEDURES

FOR EYES: Immediately flush with plenty of water for at least 15 minutes. If irritation persists, contact a physician.
FOR SKIN: Remove contaminated clothes. Immediately wash skin with plenty of water for 15 minutes. Wash clothing before reuse.
FOR INHALATION: Remove to fresh air. If breathing has stopped, give artificial respiration. Keep person warm, quiet and get medical attention.
FOR INGESTION: Not applicable - material recognized as safe

SECTION VI - PHYSICAL DATA

APPEARANCE AND ODOR: White powder or granules, odorless
SPECIFIC GRAVITY: 1.665
VAPOR PRESSURE: N.A.
VAPOR DENSITY (air=1): N.A.
EVAPORATION RATE: N.A.
BOILING POINT: N.A.



FREEZING POINT:	N.A.
SOLUBILITY IN H20:	Greater than 50 %
pH:	2.2 0.1N solution

SECTION VII - REACTIVITY DATA

CHEMICAL STABILITY:	Stable
INCOMPATIBLE MATERIALS:	Organic acids
HAZARDOUS POLYMERIZATION:	Does not polymerize
HAZARDOUS DECOMPOSITION PRODUCTS:	Carbon monoxide, carbon dioxide

SECTION VIII - SPECIAL/PERSONAL PROTECTION

VENTILATION:	The use of mechanical ventilation is recommended whenever this product is used in a confined space. Where engineering controls are not feasible, assure use is in an area where there is natural air movement.
RESPIRATORY PROTECTION:	Dust mask
PROTECTIVE GLOVES:	Standard work gloves
EYE PROTECTION:	Safety glasses
OTHER PROTECTIVE EQUIPMENT:	Eyewash bottles or other rinsing equipment should be easily accessible.

SECTION IX - HANDLING PRECAUTIONS

LEAK AND SPILL PROCEDURES:	Sweep up and place in suitable containers for reuse or disposal.
WASTE DISPOSAL:	If this product becomes a waste it may meet the requirements of a RCRA hazardous waste with the waste code D002. Always dispose of according to local/state/federal regulations.
HANDLING & SPECIAL EQUIPMENT:	Keep container tightly closed when not in use.
STORAGE REQUIREMENTS:	General chemical storage.

SECTION X - REGULATORY INFORMATION

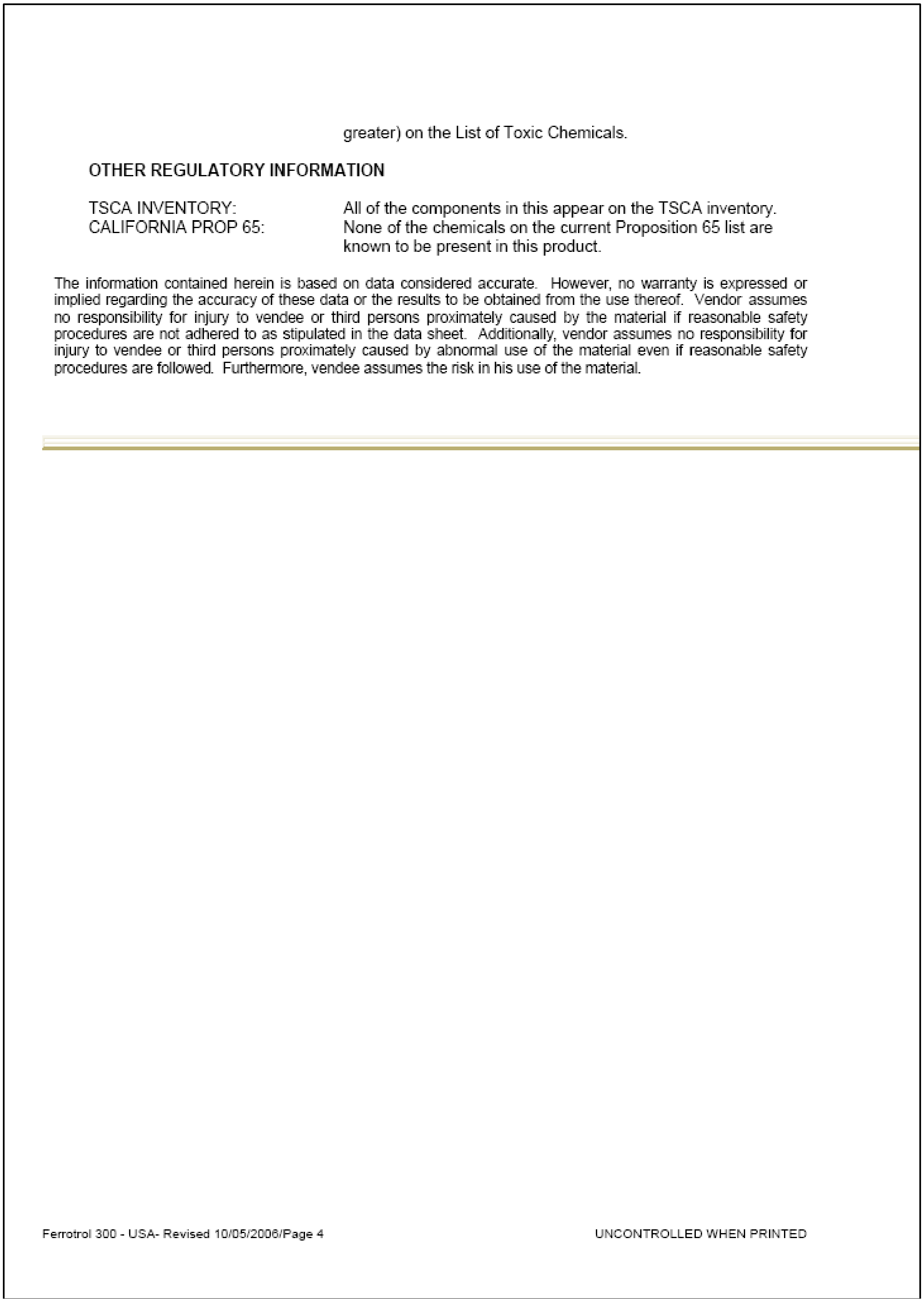
SHIPPING INFORMATION

PROPER SHIPPING NAME:	Not DOT Regulated
HAZARD CLASS:	N.A.
UN/NA NUMBER:	N.A.
PACKING GROUP W/ "PG":	N.A.
SUBSIDIARY RISK:	N.A.
REPORTABLE QUANTITY (RQ):	N.A.
EMERGENCY RESPONSE GUIDE #:	N.A.

ENVIRONMENTAL INFORMATION

SARA TITLE III

SECTION 302/304	This product does not contain ingredients listed as an Extremely Hazardous Substance.
SECTION 311/312	Immediate
SECTION 313	This product does not contain ingredients (at a level of 1% or



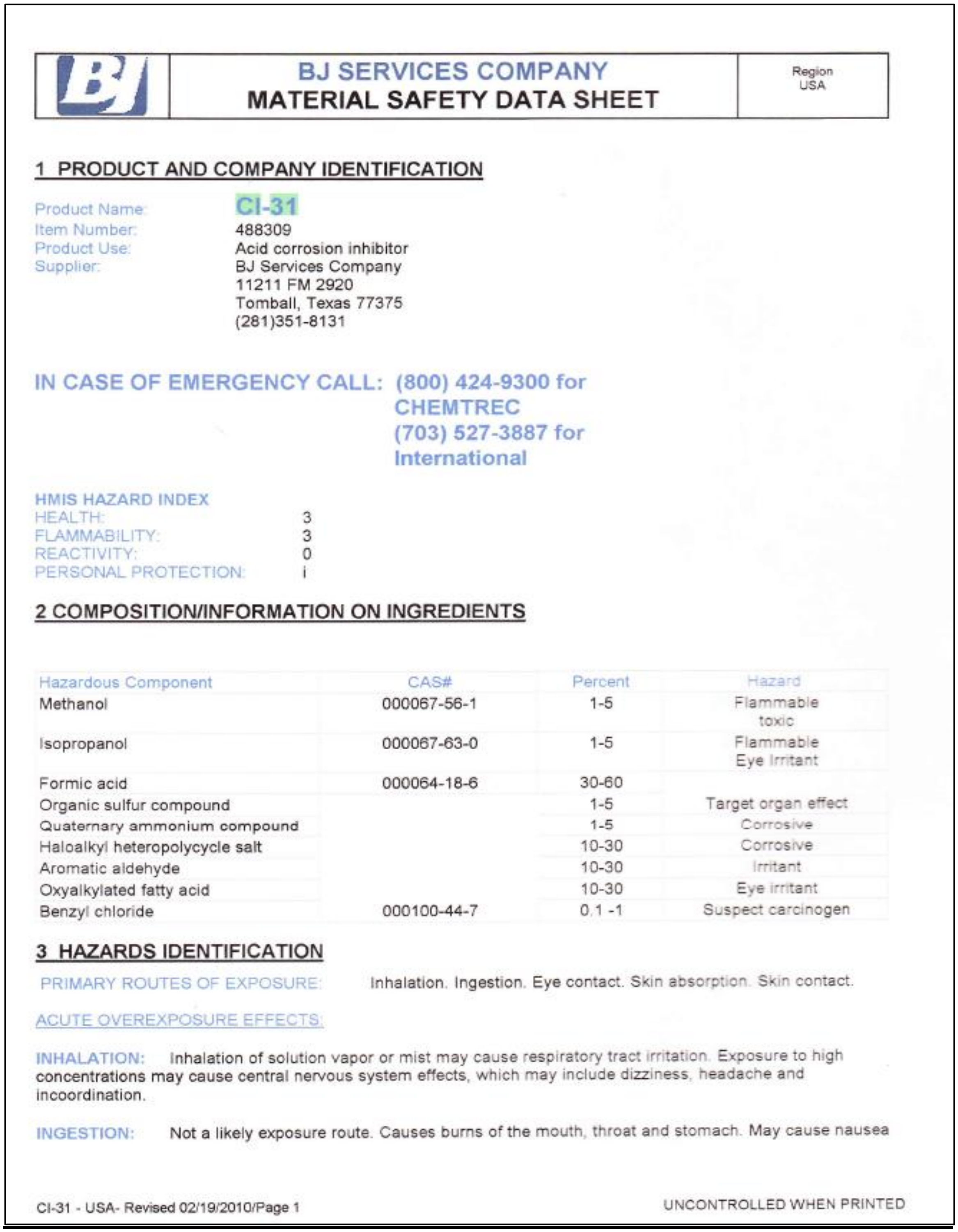
greater) on the List of Toxic Chemicals.

OTHER REGULATORY INFORMATION

TSCA INVENTORY:	All of the components in this appear on the TSCA inventory.
CALIFORNIA PROP 65:	None of the chemicals on the current Proposition 65 list are known to be present in this product.

The information contained herein is based on data considered accurate. However, no warranty is expressed or implied regarding the accuracy of these data or the results to be obtained from the use thereof. Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Additionally, vendor assumes no responsibility for injury to vendee or third persons proximately caused by abnormal use of the material even if reasonable safety procedures are followed. Furthermore, vendee assumes the risk in his use of the material.

A-3 FA-CI MSDS



BJ SERVICES COMPANY
MATERIAL SAFETY DATA SHEET

Region
USA

1 PRODUCT AND COMPANY IDENTIFICATION

Product Name:	**CI-31**
Item Number:	488309
Product Use:	Acid corrosion inhibitor
Supplier:	BJ Services Company 11211 FM 2920 Tomball, Texas 77375 (281)351-8131

IN CASE OF EMERGENCY CALL: (800) 424-9300 for CHEMTREC (703) 527-3887 for International

HMIS HAZARD INDEX

HEALTH:	3
FLAMMABILITY:	3
REACTIVITY:	0
PERSONAL PROTECTION:	i

2 COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous Component	CAS#	Percent	Hazard
Methanol	000067-56-1	1-5	Flammable toxic
Isopropanol	000067-63-0	1-5	Flammable Eye Irritant
Formic acid	000064-18-6	30-60	
Organic sulfur compound		1-5	Target organ effect
Quaternary ammonium compound		1-5	Corrosive
Haloalkyl heteropolycycle salt		10-30	Corrosive
Aromatic aldehyde		10-30	Irritant
Oxyalkylated fatty acid		10-30	Eye irritant
Benzyl chloride	000100-44-7	0.1 -1	Suspect carcinogen

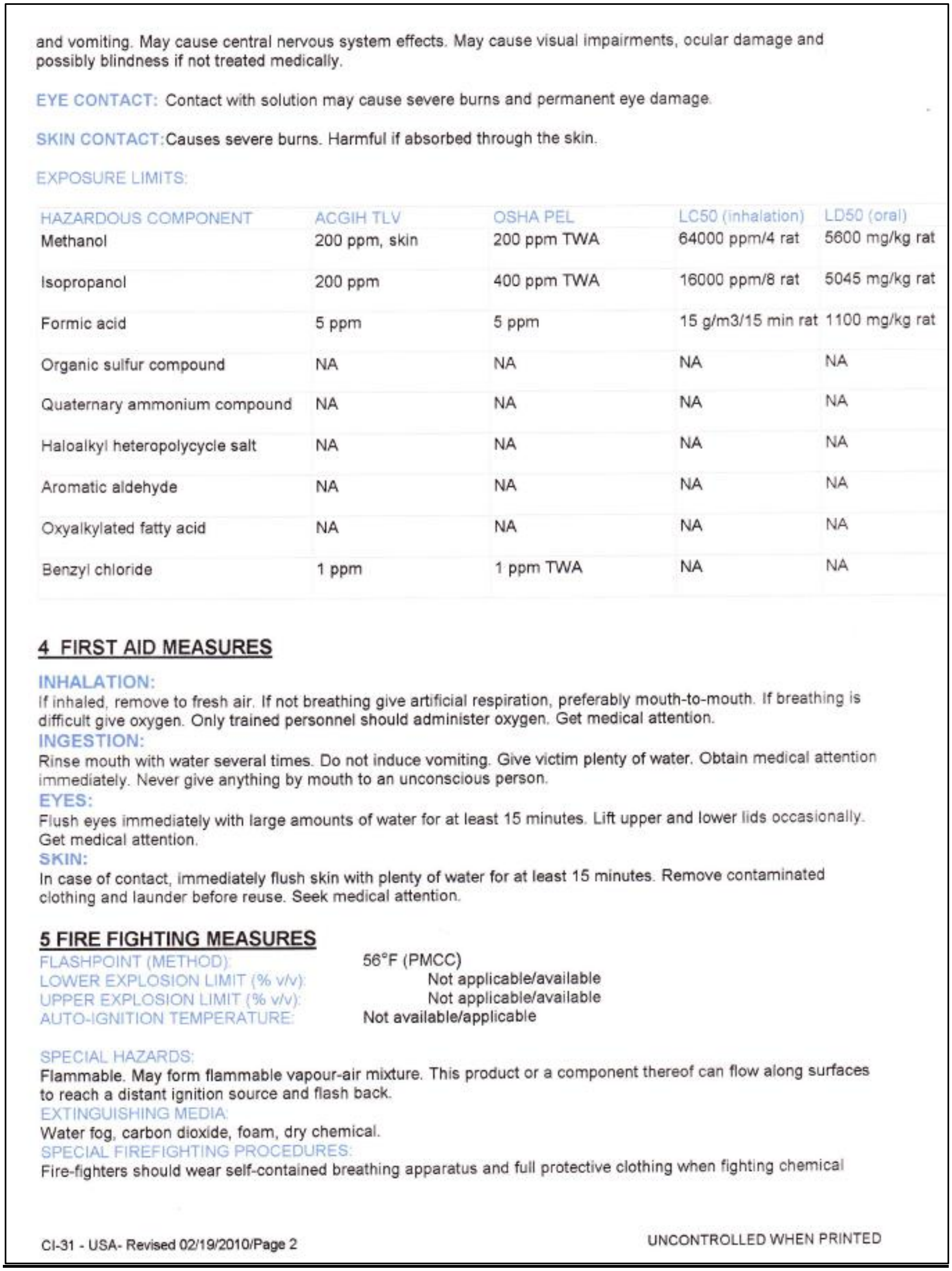
3 HAZARDS IDENTIFICATION

PRIMARY ROUTES OF EXPOSURE: Inhalation. Ingestion. Eye contact. Skin absorption. Skin contact.

ACUTE OVEREXPOSURE EFFECTS:

INHALATION: Inhalation of solution vapor or mist may cause respiratory tract irritation. Exposure to high concentrations may cause central nervous system effects, which may include dizziness, headache and incoordination.

INGESTION: Not a likely exposure route. Causes burns of the mouth, throat and stomach. May cause nausea



and vomiting. May cause central nervous system effects. May cause visual impairments, ocular damage and possibly blindness if not treated medically.

EYE CONTACT: Contact with solution may cause severe burns and permanent eye damage.

SKIN CONTACT: Causes severe burns. Harmful if absorbed through the skin.

EXPOSURE LIMITS:

HAZARDOUS COMPONENT	ACGIH TLV	OSHA PEL	LC50 (inhalation)	LD50 (oral)
Methanol	200 ppm, skin	200 ppm TWA	64000 ppm/4 rat	5600 mg/kg rat
Isopropanol	200 ppm	400 ppm TWA	16000 ppm/8 rat	5045 mg/kg rat
Formic acid	5 ppm	5 ppm	15 g/m3/15 min rat	1100 mg/kg rat
Organic sulfur compound	NA	NA	NA	NA
Quaternary ammonium compound	NA	NA	NA	NA
Haloalkyl heteropolycycle salt	NA	NA	NA	NA
Aromatic aldehyde	NA	NA	NA	NA
Oxyalkylated fatty acid	NA	NA	NA	NA
Benzyl chloride	1 ppm	1 ppm TWA	NA	NA

4 FIRST AID MEASURES

INHALATION:

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Only trained personnel should administer oxygen. Get medical attention.

INGESTION:

Rinse mouth with water several times. Do not induce vomiting. Give victim plenty of water. Obtain medical attention immediately. Never give anything by mouth to an unconscious person.

EYES:

Flush eyes immediately with large amounts of water for at least 15 minutes. Lift upper and lower lids occasionally. Get medical attention.

SKIN:

In case of contact, immediately flush skin with plenty of water for at least 15 minutes. Remove contaminated clothing and launder before reuse. Seek medical attention.

5 FIRE FIGHTING MEASURES

FLASHPOINT (METHOD):	56°F (PMCC)
LOWER EXPLOSION LIMIT (% v/v):	Not applicable/available
UPPER EXPLOSION LIMIT (% v/v):	Not applicable/available
AUTO-IGNITION TEMPERATURE:	Not available/applicable

SPECIAL HAZARDS:

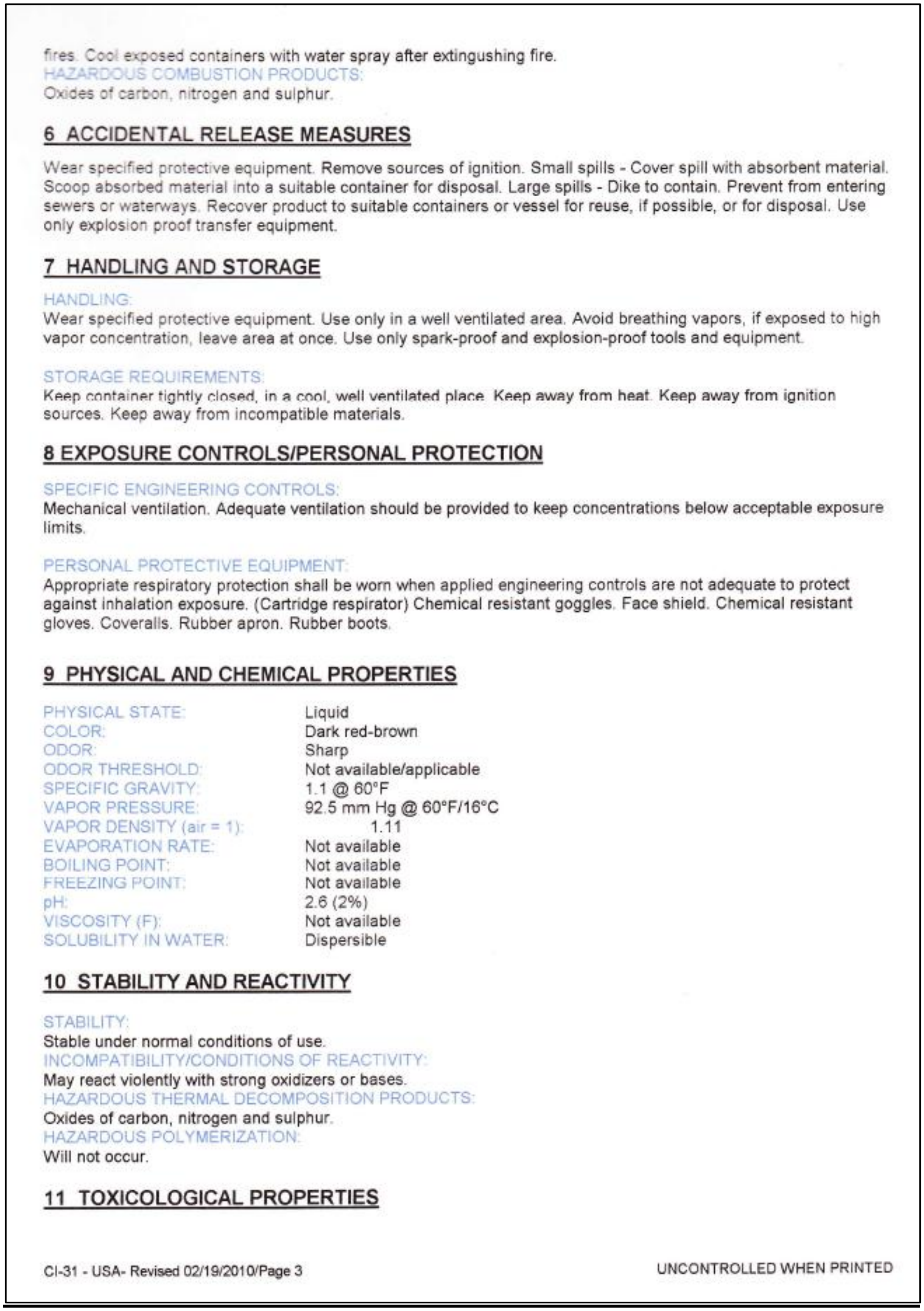
Flammable. May form flammable vapour-air mixture. This product or a component thereof can flow along surfaces to reach a distant ignition source and flash back.

EXTINGUISHING MEDIA:

Water fog, carbon dioxide, foam, dry chemical.

SPECIAL FIREFIGHTING PROCEDURES:

Fire-fighters should wear self-contained breathing apparatus and full protective clothing when fighting chemical



fires. Cool exposed containers with water spray after extingushing fire.
HAZARDOUS COMBUSTION PRODUCTS:
Oxides of carbon, nitrogen and sulphur.

6 ACCIDENTAL RELEASE MEASURES

Wear specified protective equipment. Remove sources of ignition. Small spills - Cover spill with absorbent material. Scoop absorbed material into a suitable container for disposal. Large spills - Dike to contain. Prevent from entering sewers or waterways. Recover product to suitable containers or vessel for reuse, if possible, or for disposal. Use only explosion proof transfer equipment.

7 HANDLING AND STORAGE

HANDLING:
Wear specified protective equipment. Use only in a well ventilated area. Avoid breathing vapors, if exposed to high vapor concentration, leave area at once. Use only spark-proof and explosion-proof tools and equipment.

STORAGE REQUIREMENTS:
Keep container tightly closed, in a cool, well ventilated place. Keep away from heat. Keep away from ignition sources. Keep away from incompatible materials.

8 EXPOSURE CONTROLS/PERSONAL PROTECTION

SPECIFIC ENGINEERING CONTROLS:
Mechanical ventilation. Adequate ventilation should be provided to keep concentrations below acceptable exposure limits.

PERSONAL PROTECTIVE EQUIPMENT:
Appropriate respiratory protection shall be worn when applied engineering controls are not adequate to protect against inhalation exposure. (Cartridge respirator) Chemical resistant goggles. Face shield. Chemical resistant gloves. Coveralls. Rubber apron. Rubber boots.

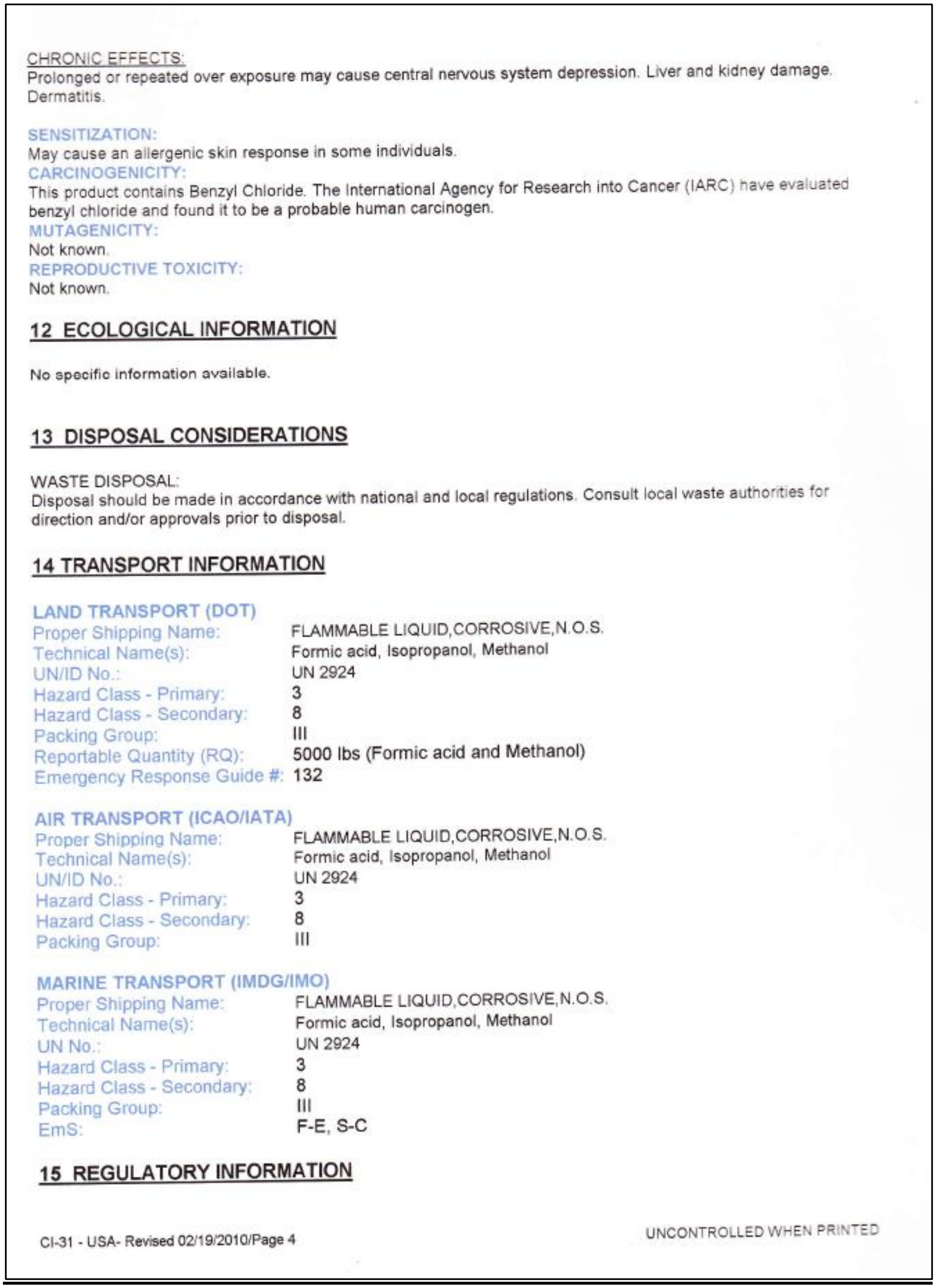
9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE:	Liquid
COLOR:	Dark red-brown
ODOR:	Sharp
ODOR THRESHOLD:	Not available/applicable
SPECIFIC GRAVITY:	1.1 @ 60°F
VAPOR PRESSURE:	92.5 mm Hg @ 60°F/16°C
VAPOR DENSITY (air = 1):	1.11
EVAPORATION RATE:	Not available
BOILING POINT:	Not available
FREEZING POINT:	Not available
pH:	2.6 (2%)
VISCOSITY (F):	Not available
SOLUBILITY IN WATER:	Dispersible

10 STABILITY AND REACTIVITY

STABILITY:
Stable under normal conditions of use.
INCOMPATIBILITY/CONDITIONS OF REACTIVITY:
May react violently with strong oxidizers or bases.
HAZARDOUS THERMAL DECOMPOSITION PRODUCTS:
Oxides of carbon, nitrogen and sulphur.
HAZARDOUS POLYMERIZATION:
Will not occur.

11 TOXICOLOGICAL PROPERTIES



CHRONIC EFFECTS:
Prolonged or repeated over exposure may cause central nervous system depression. Liver and kidney damage. Dermatitis.

SENSITIZATION:
May cause an allergenic skin response in some individuals.
CARCINOGENICITY:
This product contains Benzyl Chloride. The International Agency for Research into Cancer (IARC) have evaluated benzyl chloride and found it to be a probable human carcinogen.
MUTAGENICITY:
Not known.
REPRODUCTIVE TOXICITY:
Not known.

12 ECOLOGICAL INFORMATION

No specific information available.

13 DISPOSAL CONSIDERATIONS

WASTE DISPOSAL:
Disposal should be made in accordance with national and local regulations. Consult local waste authorities for direction and/or approvals prior to disposal.

14 TRANSPORT INFORMATION

LAND TRANSPORT (DOT)

Proper Shipping Name:	FLAMMABLE LIQUID,CORROSIVE,N.O.S.
Technical Name(s):	Formic acid, Isopropanol, Methanol
UN/ID No.:	UN 2924
Hazard Class - Primary:	3
Hazard Class - Secondary:	8
Packing Group:	III
Reportable Quantity (RQ):	5000 lbs (Formic acid and Methanol)
Emergency Response Guide #:	132

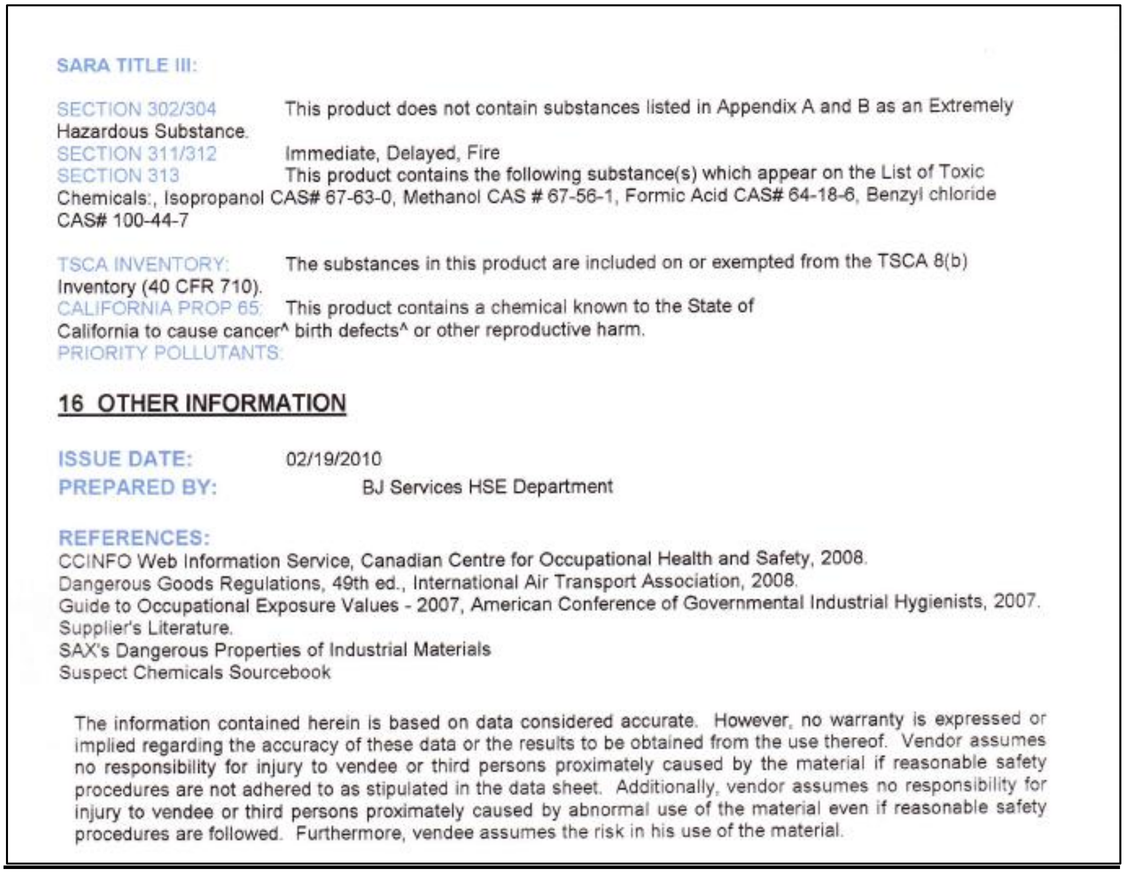
AIR TRANSPORT (ICAO/IATA)

Proper Shipping Name:	FLAMMABLE LIQUID,CORROSIVE,N.O.S.
Technical Name(s):	Formic acid, Isopropanol, Methanol
UN/ID No.:	UN 2924
Hazard Class - Primary:	3
Hazard Class - Secondary:	8
Packing Group:	III

MARINE TRANSPORT (IMDG/IMO)

Proper Shipping Name:	FLAMMABLE LIQUID,CORROSIVE,N.O.S.
Technical Name(s):	Formic acid, Isopropanol, Methanol
UN No.:	UN 2924
Hazard Class - Primary:	3
Hazard Class - Secondary:	8
Packing Group:	III
EmS:	F-E, S-C

15 REGULATORY INFORMATION



SARA TITLE III:

SECTION 302/304 This product does not contain substances listed in Appendix A and B as an Extremely Hazardous Substance.

SECTION 311/312 Immediate, Delayed, Fire

SECTION 313 This product contains the following substance(s) which appear on the List of Toxic Chemicals:, Isopropanol CAS# 67-63-0, Methanol CAS # 67-56-1, Formic Acid CAS# 64-18-6, Benzyl chloride CAS# 100-44-7

TSCA INVENTORY: The substances in this product are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710).

CALIFORNIA PROP 65: This product contains a chemical known to the State of California to cause cancer^ birth defects^ or other reproductive harm.

PRIORITY POLLUTANTS:

16 OTHER INFORMATION

ISSUE DATE: 02/19/2010

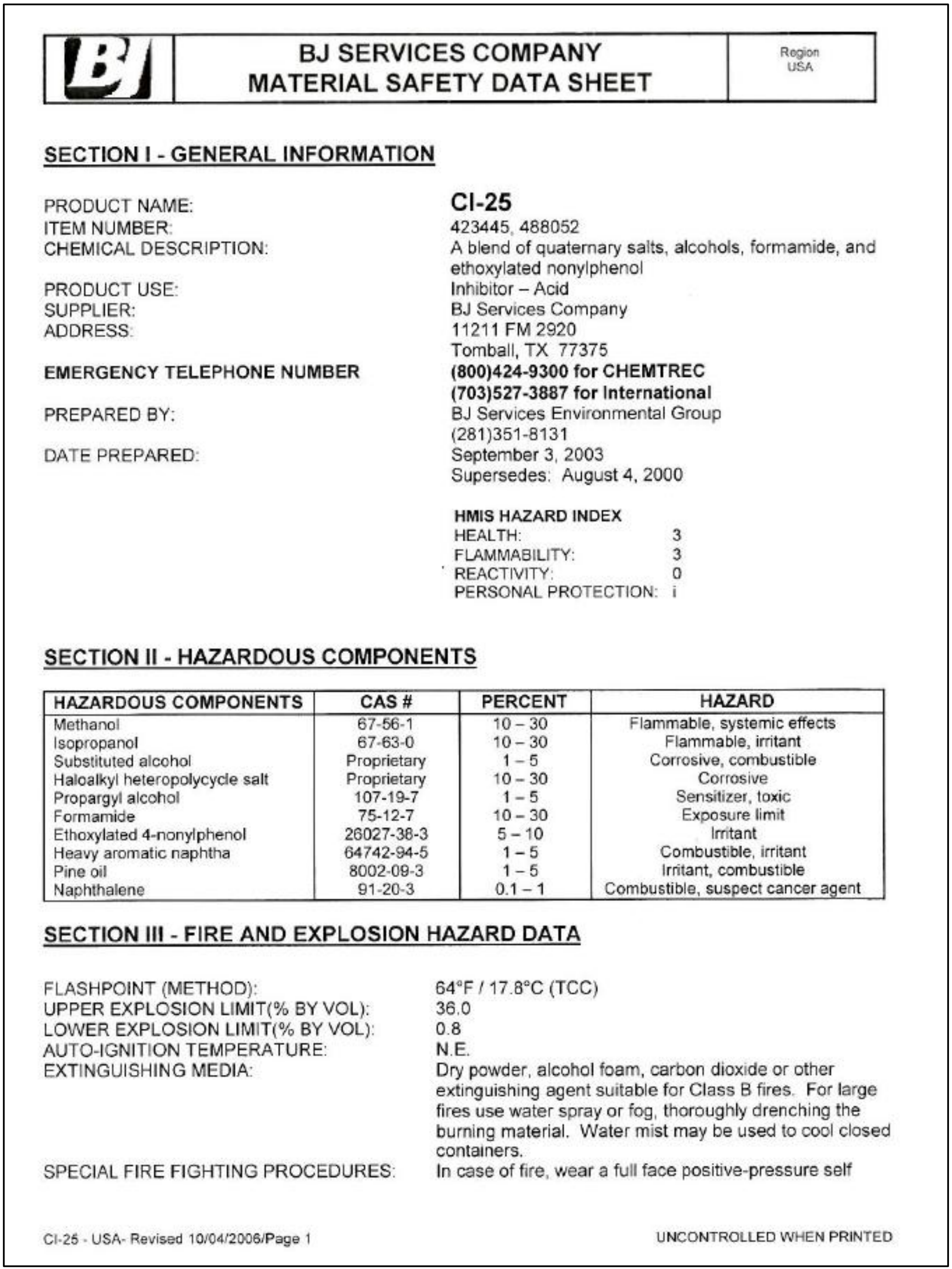
PREPARED BY: BJ Services HSE Department

REFERENCES:

CCINFO Web Information Service, Canadian Centre for Occupational Health and Safety, 2008.
Dangerous Goods Regulations, 49th ed., International Air Transport Association, 2008.
Guide to Occupational Exposure Values - 2007, American Conference of Governmental Industrial Hygienists, 2007.
Supplier's Literature.
SAX's Dangerous Properties of Industrial Materials
Suspect Chemicals Sourcebook

The information contained herein is based on data considered accurate. However, no warranty is expressed or implied regarding the accuracy of these data or the results to be obtained from the use thereof. Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Additionally, vendor assumes no responsibility for injury to vendee or third persons proximately caused by abnormal use of the material even if reasonable safety procedures are followed. Furthermore, vendee assumes the risk in his use of the material.

A-4 MI-CI MSDS



BJ SERVICES COMPANY
MATERIAL SAFETY DATA SHEET

Region
USA

SECTION I - GENERAL INFORMATION

PRODUCT NAME:	**CI-25**
ITEM NUMBER:	423445, 488052
CHEMICAL DESCRIPTION:	A blend of quaternary salts, alcohols, formamide, and ethoxylated nonylphenol
PRODUCT USE:	Inhibitor – Acid
SUPPLIER:	BJ Services Company
ADDRESS:	11211 FM 2920 Tomball, TX 77375
EMERGENCY TELEPHONE NUMBER	**(800)424-9300 for CHEMTREC** **(703)527-3887 for International**
PREPARED BY:	BJ Services Environmental Group (281)351-8131
DATE PREPARED:	September 3, 2003 Supersedes: August 4, 2000

HMIS HAZARD INDEX

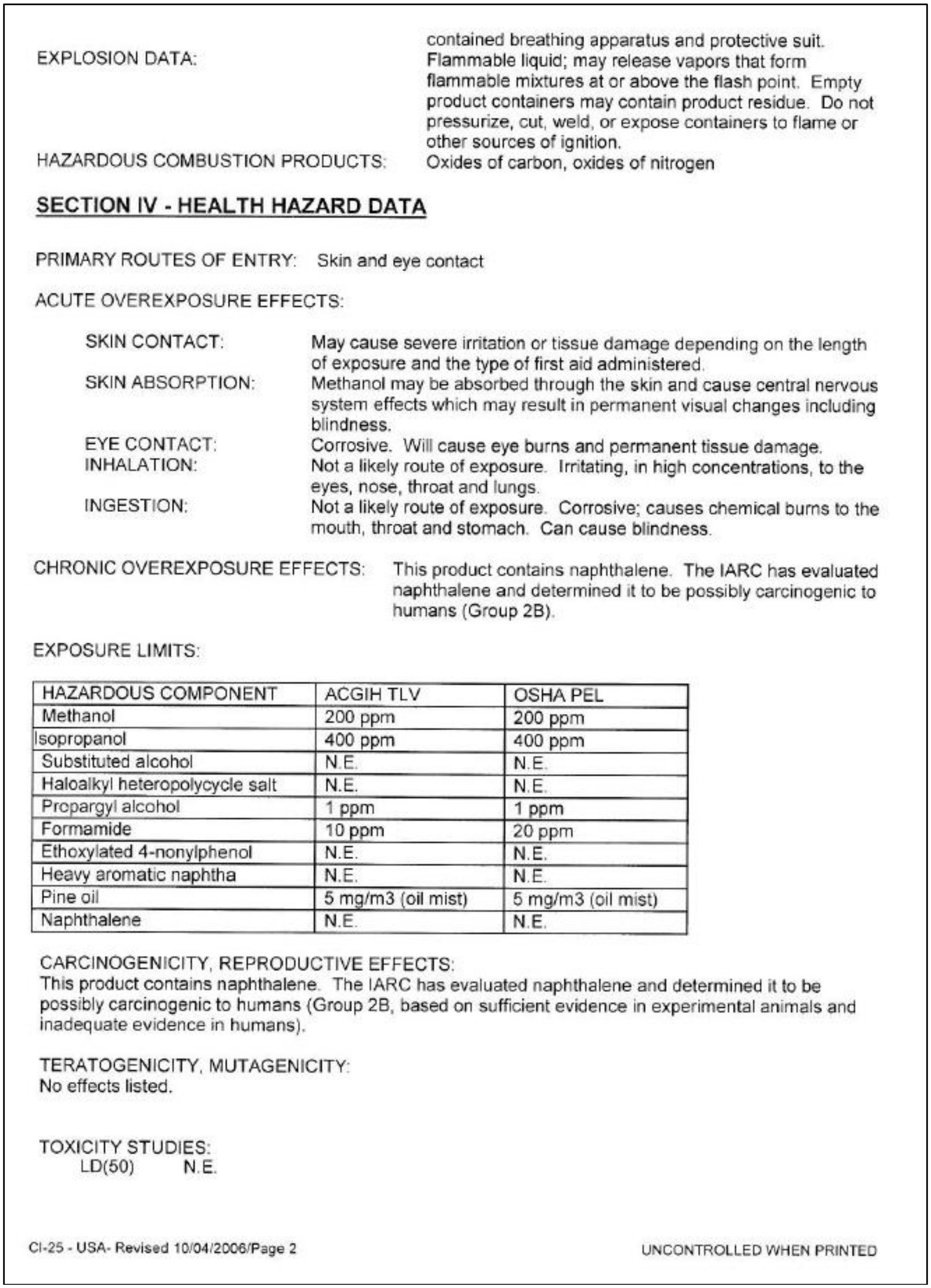
HEALTH:	3
FLAMMABILITY:	3
REACTIVITY:	0
PERSONAL PROTECTION:	i

SECTION II - HAZARDOUS COMPONENTS

HAZARDOUS COMPONENTS	CAS #	PERCENT	HAZARD
Methanol	67-56-1	10 – 30	Flammable, systemic effects
Isopropanol	67-63-0	10 – 30	Flammable, irritant
Substituted alcohol	Proprietary	1 – 5	Corrosive, combustible
Haloalkyl heteropolycycle salt	Proprietary	10 – 30	Corrosive
Propargyl alcohol	107-19-7	1 – 5	Sensitizer, toxic
Formamide	75-12-7	10 – 30	Exposure limit
Ethoxylated 4-nonylphenol	26027-38-3	5 – 10	Irritant
Heavy aromatic naphtha	64742-94-5	1 – 5	Combustible, irritant
Pine oil	8002-09-3	1 – 5	Irritant, combustible
Naphthalene	91-20-3	0.1 – 1	Combustible, suspect cancer agent

SECTION III - FIRE AND EXPLOSION HAZARD DATA

FLASHPOINT (METHOD):	64°F / 17.8°C (TCC)
UPPER EXPLOSION LIMIT(% BY VOL):	36.0
LOWER EXPLOSION LIMIT(% BY VOL):	0.8
AUTO-IGNITION TEMPERATURE:	N.E.
EXTINGUISHING MEDIA:	Dry powder, alcohol foam, carbon dioxide or other extinguishing agent suitable for Class B fires. For large fires use water spray or fog, thoroughly drenching the burning material. Water mist may be used to cool closed containers.
SPECIAL FIRE FIGHTING PROCEDURES:	In case of fire, wear a full face positive-pressure self



	contained breathing apparatus and protective suit.
EXPLOSION DATA:	Flammable liquid; may release vapors that form flammable mixtures at or above the flash point. Empty product containers may contain product residue. Do not pressurize, cut, weld, or expose containers to flame or other sources of ignition.
HAZARDOUS COMBUSTION PRODUCTS:	Oxides of carbon, oxides of nitrogen

SECTION IV - HEALTH HAZARD DATA

PRIMARY ROUTES OF ENTRY: Skin and eye contact

ACUTE OVEREXPOSURE EFFECTS:

SKIN CONTACT:	May cause severe irritation or tissue damage depending on the length of exposure and the type of first aid administered.
SKIN ABSORPTION:	Methanol may be absorbed through the skin and cause central nervous system effects which may result in permanent visual changes including blindness.
EYE CONTACT:	Corrosive. Will cause eye burns and permanent tissue damage.
INHALATION:	Not a likely route of exposure. Irritating, in high concentrations, to the eyes, nose, throat and lungs.
INGESTION:	Not a likely route of exposure. Corrosive; causes chemical burns to the mouth, throat and stomach. Can cause blindness.

CHRONIC OVEREXPOSURE EFFECTS: This product contains naphthalene. The IARC has evaluated naphthalene and determined it to be possibly carcinogenic to humans (Group 2B).

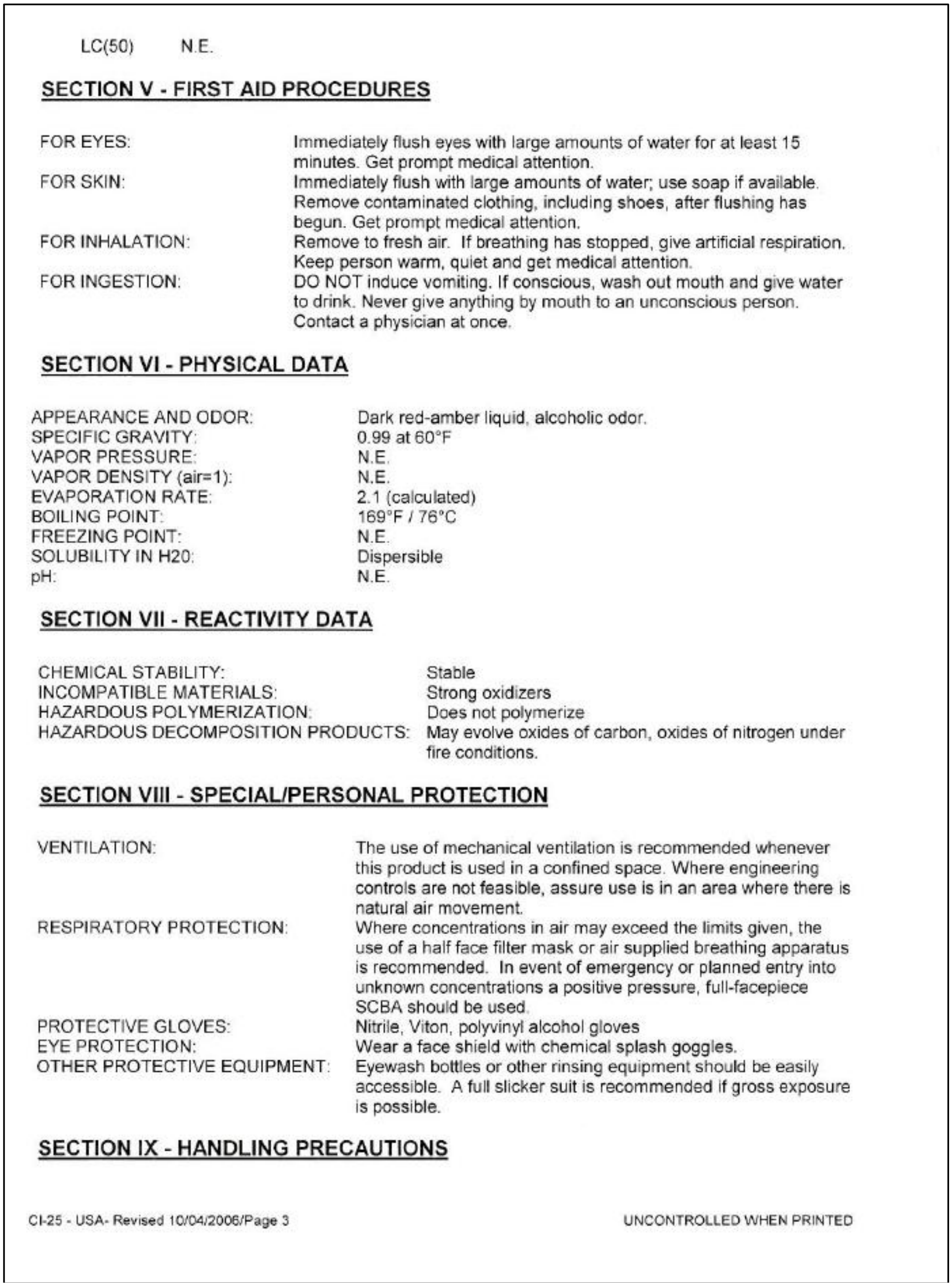
EXPOSURE LIMITS:

HAZARDOUS COMPONENT	ACGIH TLV	OSHA PEL
Methanol	200 ppm	200 ppm
Isopropanol	400 ppm	400 ppm
Substituted alcohol	N.E.	N.E.
Haloalkyl heteropolycycle salt	N.E.	N.E.
Propargyl alcohol	1 ppm	1 ppm
Formamide	10 ppm	20 ppm
Ethoxylated 4-nonylphenol	N.E.	N.E.
Heavy aromatic naphtha	N.E.	N.E.
Pine oil	5 mg/m3 (oil mist)	5 mg/m3 (oil mist)
Naphthalene	N.E.	N.E.

CARCINOGENICITY, REPRODUCTIVE EFFECTS:
This product contains naphthalene. The IARC has evaluated naphthalene and determined it to be possibly carcinogenic to humans (Group 2B, based on sufficient evidence in experimental animals and inadequate evidence in humans).

TERATOGENICITY, MUTAGENICITY:
No effects listed.

TOXICITY STUDIES:
LD(50) N.E.



LC(50)	N.E.

SECTION V - FIRST AID PROCEDURES

FOR EYES:	Immediately flush eyes with large amounts of water for at least 15 minutes. Get prompt medical attention.
FOR SKIN:	Immediately flush with large amounts of water; use soap if available. Remove contaminated clothing, including shoes, after flushing has begun. Get prompt medical attention.
FOR INHALATION:	Remove to fresh air. If breathing has stopped, give artificial respiration. Keep person warm, quiet and get medical attention.
FOR INGESTION:	DO NOT induce vomiting. If conscious, wash out mouth and give water to drink. Never give anything by mouth to an unconscious person. Contact a physician at once.

SECTION VI - PHYSICAL DATA

APPEARANCE AND ODOR:	Dark red-amber liquid, alcoholic odor.
SPECIFIC GRAVITY:	0.99 at 60°F
VAPOR PRESSURE:	N.E.
VAPOR DENSITY (air=1):	N.E.
EVAPORATION RATE:	2.1 (calculated)
BOILING POINT:	169°F / 76°C
FREEZING POINT:	N.E.
SOLUBILITY IN H20:	Dispersible
pH:	N.E.

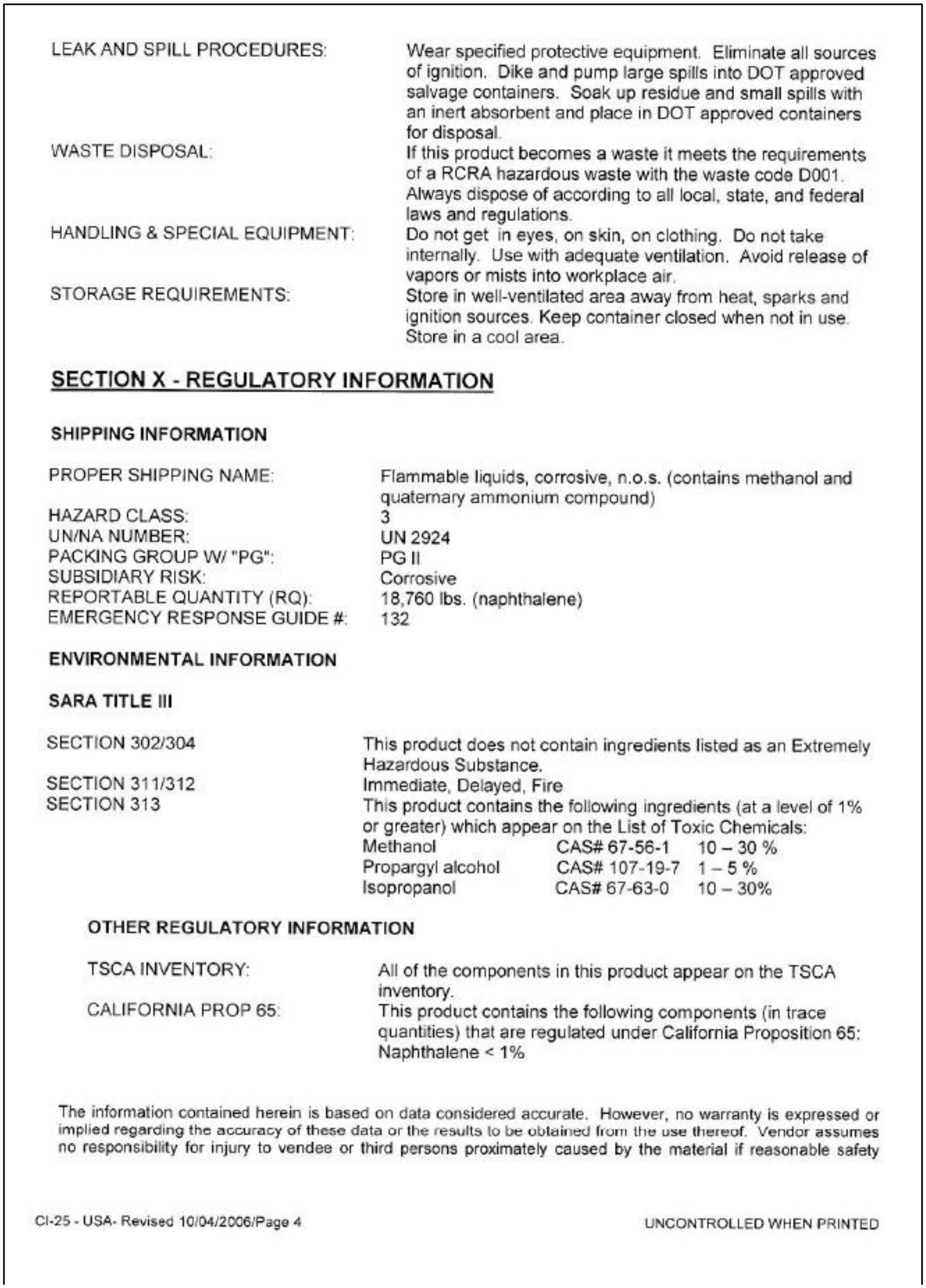
SECTION VII - REACTIVITY DATA

CHEMICAL STABILITY:	Stable
INCOMPATIBLE MATERIALS:	Strong oxidizers
HAZARDOUS POLYMERIZATION:	Does not polymerize
HAZARDOUS DECOMPOSITION PRODUCTS:	May evolve oxides of carbon, oxides of nitrogen under fire conditions.

SECTION VIII - SPECIAL/PERSONAL PROTECTION

VENTILATION:	The use of mechanical ventilation is recommended whenever this product is used in a confined space. Where engineering controls are not feasible, assure use is in an area where there is natural air movement.
RESPIRATORY PROTECTION:	Where concentrations in air may exceed the limits given, the use of a half face filter mask or air supplied breathing apparatus is recommended. In event of emergency or planned entry into unknown concentrations a positive pressure, full-facepiece SCBA should be used.
PROTECTIVE GLOVES:	Nitrile, Viton, polyvinyl alcohol gloves
EYE PROTECTION:	Wear a face shield with chemical splash goggles.
OTHER PROTECTIVE EQUIPMENT:	Eyewash bottles or other rinsing equipment should be easily accessible. A full slicker suit is recommended if gross exposure is possible.

SECTION IX - HANDLING PRECAUTIONS



LEAK AND SPILL PROCEDURES:	Wear specified protective equipment. Eliminate all sources of ignition. Dike and pump large spills into DOT approved salvage containers. Soak up residue and small spills with an inert absorbent and place in DOT approved containers for disposal.
WASTE DISPOSAL:	If this product becomes a waste it meets the requirements of a RCRA hazardous waste with the waste code D001. Always dispose of according to all local, state, and federal laws and regulations.
HANDLING & SPECIAL EQUIPMENT:	Do not get in eyes, on skin, on clothing. Do not take internally. Use with adequate ventilation. Avoid release of vapors or mists into workplace air.
STORAGE REQUIREMENTS:	Store in well-ventilated area away from heat, sparks and ignition sources. Keep container closed when not in use. Store in a cool area.

SECTION X - REGULATORY INFORMATION

SHIPPING INFORMATION

PROPER SHIPPING NAME:	Flammable liquids, corrosive, n.o.s. (contains methanol and quaternary ammonium compound)
HAZARD CLASS:	3
UN/NA NUMBER:	UN 2924
PACKING GROUP W/ "PG":	PG II
SUBSIDIARY RISK:	Corrosive
REPORTABLE QUANTITY (RQ):	18,760 lbs. (naphthalene)
EMERGENCY RESPONSE GUIDE #:	132

ENVIRONMENTAL INFORMATION

SARA TITLE III

SECTION 302/304	This product does not contain ingredients listed as an Extremely Hazardous Substance.
SECTION 311/312	Immediate, Delayed, Fire
SECTION 313	This product contains the following ingredients (at a level of 1% or greater) which appear on the List of Toxic Chemicals:

Methanol	CAS# 67-56-1	10 – 30 %
Propargyl alcohol	CAS# 107-19-7	1 – 5 %
Isopropanol	CAS# 67-63-0	10 – 30%

OTHER REGULATORY INFORMATION

TSCA INVENTORY:	All of the components in this product appear on the TSCA inventory.
CALIFORNIA PROP 65:	This product contains the following components (in trace quantities) that are regulated under California Proposition 65: Naphthalene < 1%

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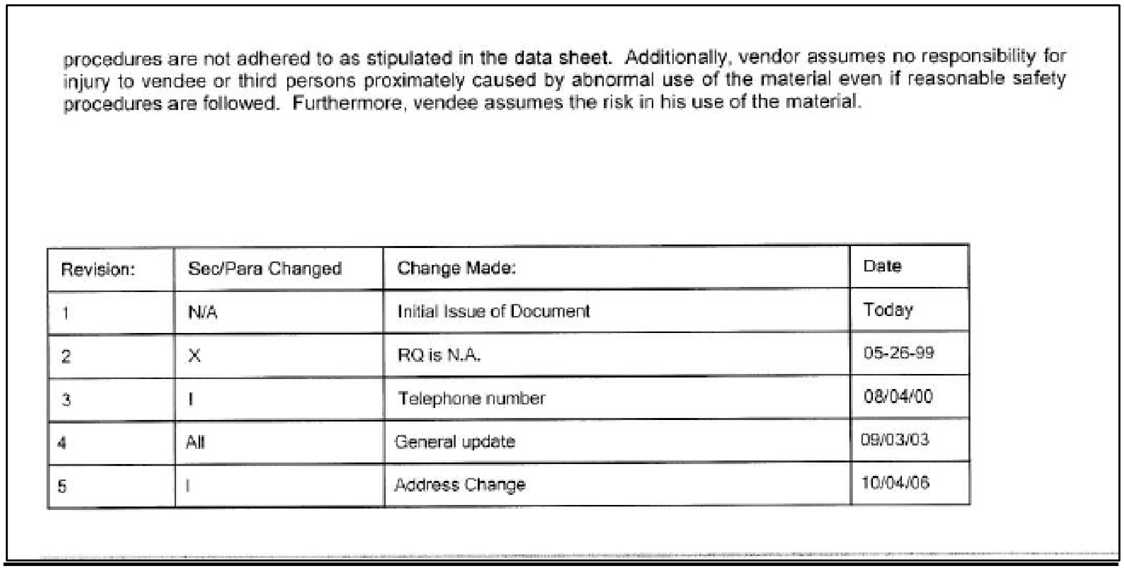
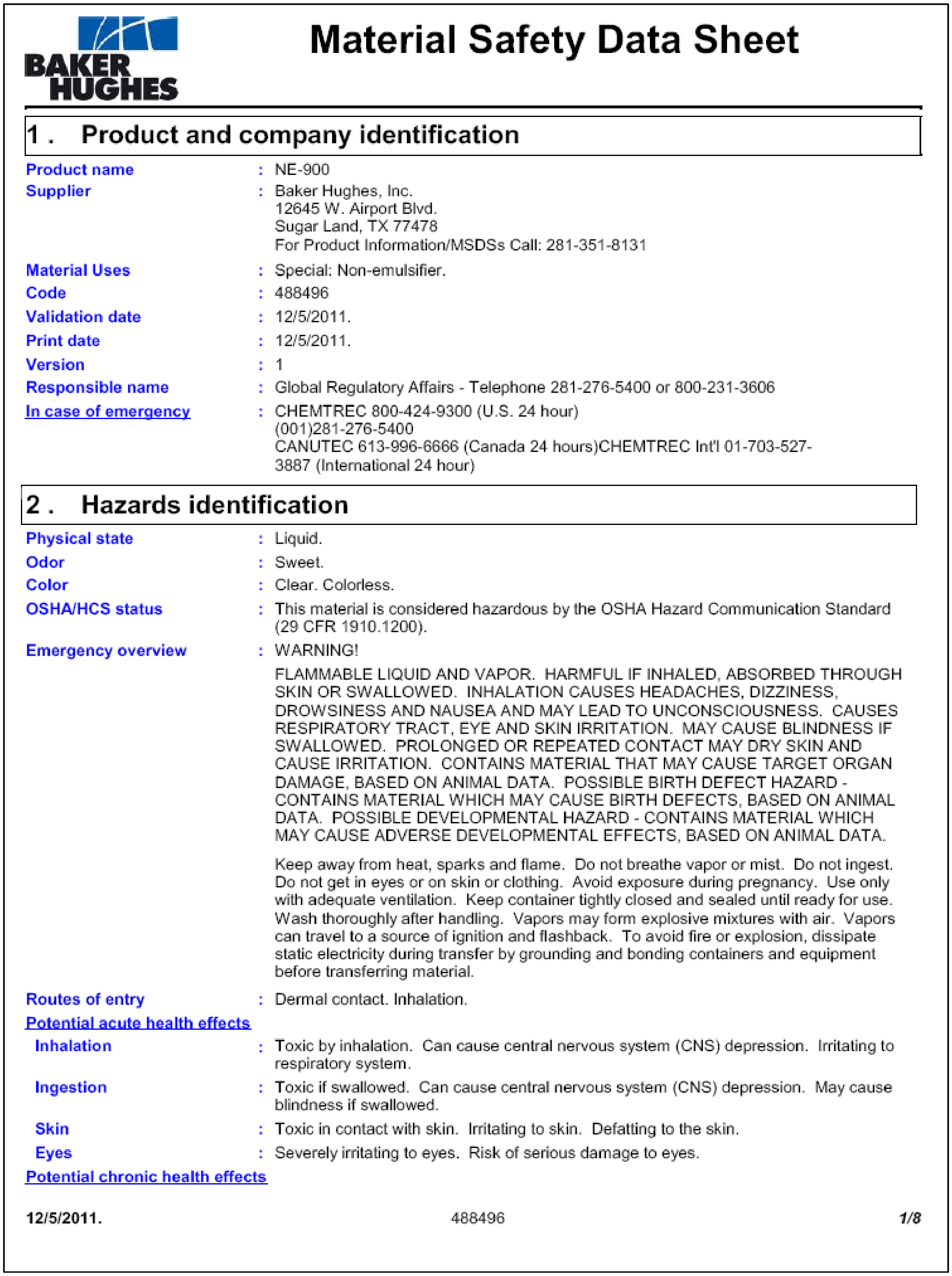


procedures are not adhered to as stipulated in the data sheet. Additionally, vendor assumes no responsibility for injury to vendee or third persons proximately caused by abnormal use of the material even if reasonable safety procedures are followed. Furthermore, vendee assumes the risk in his use of the material.

Revision:	Sec/Para Changed	Change Made:	Date
1	N/A	Initial Issue of Document	Today
2	X	RQ is N.A.	05-26-99
3	I	Telephone number	08/04/00
4	All	General update	09/03/03
5	I	Address Change	10/04/06

A-5 M-NEA MSDS



BAKER HUGHES

Material Safety Data Sheet

1 . Product and company identification

Product name	:	NE-900
Supplier	:	Baker Hughes, Inc. 12645 W. Airport Blvd. Sugar Land, TX 77478 For Product Information/MSDSs Call: 281-351-8131
Material Uses	:	Special: Non-emulsifier.
Code	:	488496
Validation date	:	12/5/2011.
Print date	:	12/5/2011.
Version	:	1
Responsible name	:	Global Regulatory Affairs - Telephone 281-276-5400 or 800-231-3606
In case of emergency	:	CHEMTREC 800-424-9300 (U.S. 24 hour) (001)281-276-5400 CANUTEC 613-996-6666 (Canada 24 hours)CHEMTREC Int'l 01-703-527-3887 (International 24 hour)

2 . Hazards identification

Physical state	:	Liquid.
Odor	:	Sweet.
Color	:	Clear. Colorless.
OSHA/HCS status	:	This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).
Emergency overview	:	WARNING! FLAMMABLE LIQUID AND VAPOR. HARMFUL IF INHALED, ABSORBED THROUGH SKIN OR SWALLOWED. INHALATION CAUSES HEADACHES, DIZZINESS, DROWSINESS AND NAUSEA AND MAY LEAD TO UNCONSCIOUSNESS. CAUSES RESPIRATORY TRACT, EYE AND SKIN IRRITATION. MAY CAUSE BLINDNESS IF SWALLOWED. PROLONGED OR REPEATED CONTACT MAY DRY SKIN AND CAUSE IRRITATION. CONTAINS MATERIAL THAT MAY CAUSE TARGET ORGAN DAMAGE, BASED ON ANIMAL DATA. POSSIBLE BIRTH DEFECT HAZARD - CONTAINS MATERIAL WHICH MAY CAUSE BIRTH DEFECTS, BASED ON ANIMAL DATA. POSSIBLE DEVELOPMENTAL HAZARD - CONTAINS MATERIAL WHICH MAY CAUSE ADVERSE DEVELOPMENTAL EFFECTS, BASED ON ANIMAL DATA. Keep away from heat, sparks and flame. Do not breathe vapor or mist. Do not ingest. Do not get in eyes or on skin or clothing. Avoid exposure during pregnancy. Use only with adequate ventilation. Keep container tightly closed and sealed until ready for use. Wash thoroughly after handling. Vapors may form explosive mixtures with air. Vapors can travel to a source of ignition and flashback. To avoid fire or explosion, dissipate static electricity during transfer by grounding and bonding containers and equipment before transferring material.
Routes of entry	:	Dermal contact. Inhalation.
Potential acute health effects		
Inhalation	:	Toxic by inhalation. Can cause central nervous system (CNS) depression. Irritating to respiratory system.
Ingestion	:	Toxic if swallowed. Can cause central nervous system (CNS) depression. May cause blindness if swallowed.
Skin	:	Toxic in contact with skin. Irritating to skin. Defatting to the skin.
Eyes	:	Severely irritating to eyes. Risk of serious damage to eyes.
Potential chronic health effects		

2 . Hazards identification

Chronic effects	: Contains material that may cause target organ damage, based on animal data. Prolonged or repeated contact can defat the skin and lead to irritation, cracking and/or dermatitis.
Teratogenicity	: Contains material which may cause birth defects, based on animal data.
Developmental effects	: Contains material which may cause developmental abnormalities, based on animal data.
Target organs	: Contains material which may cause damage to the following organs: gastrointestinal tract, upper respiratory tract, skin, eyes, central nervous system (CNS).

Over-exposure signs/symptoms

Inhalation	: respiratory tract irritation, nausea or vomiting, coughing, headache, drowsiness/fatigue, dizziness/vertigo, unconsciousness
Ingestion	: None known.
Skin	: irritation, redness, dryness, cracking
Eyes	: pain or irritation, watering, redness
Medical conditions aggravated by over-exposure	: Pre-existing disorders involving any target organs mentioned in this MSDS as being at risk may be aggravated by over-exposure to this product.

See toxicological information (Section 11)

3 . Composition/information on ingredients

Name	CAS number	%
Methanol	67-56-1	10 - 30
Oxyalkylated alkylphenol	9016-45-9	5 - 10

4 . First aid measures

Eye contact	: Get medical attention immediately. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids.
Skin contact	: In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.
Inhalation	: Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.
Ingestion	: Wash out mouth with water. Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Protection of first-aiders	: No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wear suitable protective clothing and gloves. Remove contaminated clothing and shoes.

5 . Fire-fighting measures

Flammability of the product	: Flammable liquid. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. Runoff to sewer may create fire or explosion hazard.

Extinguishing media

Suitable	: Use dry chemical, CO_2, water spray (fog) or foam.
Not suitable	: Do not use water jet.

5 . Fire-fighting measures

Special exposure hazards	: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.
Hazardous thermal decomposition products	: carbon dioxide,carbon monoxide
Special protective equipment for fire-fighters	: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

6 . Accidental release measures

Personal precautions	: No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Do not breathe vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see Section 8).
Environmental precautions	: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.
Methods for cleaning up	
Small spill	: Stop leak if without risk. Move containers from spill area. Absorb with an inert material. Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor.
Large spill	: Stop leak if without risk. Move containers from spill area. Approach release from upwind. Dike spill area and do not allow product to reach sewage system or surface or ground water. Notify any reportable spill to authorities. (See section 12 for environmental risks and 13 for disposal information.) Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see section 13). Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see section 1 for emergency contact information and section 13 for waste disposal.

If RQ (Reportable Quantity) is exceeded, report to National Spill Response Office at 1-800-424-8802.

7 . Handling and storage

Handling	: Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Avoid exposure during pregnancy. Do not get in eyes or on skin or clothing. Do not breathe vapor or mist. Do not ingest. Use only with adequate ventilation. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use non-sparking tools. Take precautionary measures against electrostatic discharges. To avoid fire or explosion, dissipate static electricity during transfer by grounding and bonding containers and equipment before transferring material. Empty containers retain product residue and can be hazardous. Do not reuse container.
Storage	: Store in accordance with local regulations. Store in a segregated and approved area. Store in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

8 . Exposure controls/personal protection

Occupational exposure limits		**TWA (8 hours)**			**STEL (15 mins)**			**Ceiling**			
Ingredients:	**List name**	**ppm**	**mg/m³**	**Other**	**ppm**	**mg/m³**	**Other**	**ppm**	**mg/m³**	**Other**	**Notations**
Methanol	US ACGIH	200	262	-	250	328	-	-	-	-	[1]
	OSHA PEL	200	260	-	-	-	-	-	-	-	
	OSHA PEL 1989	200	260	-	250	325	-	-	-	-	[1]

[1]Absorbed through skin.

Consult local authorities for acceptable exposure limits.

Only components of this product with established exposure limits appear in the box above.

If OSHA permissible exposure levels are shown above they are the OSHA 1989 levels or are from subsequent OSHA regulatory actions. Although the 1989 levels have been vacated the 11th Circuit Court of Appeals, Baker Hughes recommends that these lower exposure levels be observed as reasonable worker protection.

Recommended monitoring procedures : If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Engineering measures : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. Use explosion-proof ventilation equipment.

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Ensure that eyewash stations and safety showers are close to the workstation location. Take off contaminated clothing and wash before reuse.

Personal protection

Respiratory : If a risk assessment indicates it is necessary, use a properly fitted supplied air respirator complying with an approved standard. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Hands : Chemical-resistant gloves: nitrile rubber

Eyes : Wear chemical safety goggles. When transferring material wear face-shield in addition to chemical safety goggles.

Skin : Wear long sleeves and other protective clothing to prevent repeated or prolonged skin contact.

9 . Physical and chemical properties

Physical state	: Liquid.
Flash point	: Closed cup: 33.89°C (93°F)
Auto-ignition temperature	: Not available.
Flammable limits	: Lower: 6% Upper: 36%
Color	: Clear. Colorless.
Odor	: Sweet.
pH	: 9.09
Boiling/condensation point	: Not available.
Initial Boiling Point	: Not available.
Melting/freezing point	: -34.44°C (-30°F)
Relative density	: 0.97
Density	: 8.13 (lbs/gal)
Vapor density	: Not available.
Odor threshold	: Not available.
Evaporation rate	: Not available.

9 . Physical and chemical properties

VOC	: Not available.
Viscosity	: Not available.
Solubility (Water)	: Complete.
Vapor pressure	: Not available.
Pour Point	: Not available.
Partition coefficient (LogKow)	: Not available.

10 . Stability and Reactivity

Chemical stability	: The product is stable.
Possibility of hazardous reactions	: Under normal conditions of storage and use, hazardous reactions will not occur.
Hazardous polymerization	: Under normal conditions of storage and use, hazardous polymerization will not occur.
Conditions to avoid	: Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.
Materials to avoid	: Reactive or incompatible with the following materials: oxidizing materials.
Hazardous decomposition products	: Under normal conditions of storage and use, hazardous decomposition products should not be produced.
Conditions of reactivity	: Highly flammable in the presence of the following materials or conditions: open flames, sparks and static discharge and heat.

11 . Toxicological information

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
Methanol	LD50 Dermal	Rabbit	15800 mg/kg	-
	LD50 Oral	Rabbit	14200 mg/kg	-
	LD50 Oral	Rat	5600 mg/kg	-
	LC50 Inhalation Gas.	Rat	145000 ppm	1 hours
	LC50 Inhalation Gas.	Rat	64000 ppm	8 hours
	LC50 Inhalation Gas.	Rat	64000 ppm	4 hours

Chronic toxicity Remarks

1) Methanol

Not available.

2) Oxyalkylated alkylphenol

Not available.

12 . Ecological information

Aquatic ecotoxicity

Product/ingredient name	Result	Species	Exposure
Methanol	Acute LC50 2500000 ug/L Marine water	Crustaceans - Common shrimp, sand shrimp - Crangon crangon - Adult	48 hours
	Acute LC50 3289 mg/L Fresh water	Daphnia - Water flea - Daphnia magna - Neonate - <24 hours	48 hours
	Acute LC50 >100000 ug/L Fresh water	Fish - Fathead minnow - Pimephales promelas - Juvenile	96 hours

12 . Ecological information

		(Fledgling, Hatchling, Weanling) - 0.2 to 0.5 g	
Oxyalkylated alkylphenol	Acute LC50 1 to 2 ug/L Fresh water	Crustaceans - Fairy shrimp - Thamnocephalus platyurus - Nauplii - 24 hours	48 hours
	Acute LC50 4800 ug/L Fresh water	Daphnia - Water flea - Daphnia pulex - LARVAE - <=24 hours	48 hours
	Acute LC50 1300 ug/L Fresh water	Fish - Bluegill - Lepomis macrochirus - 1 g	96 hours

Conclusion/Summary : Not available.

Biodegradability

Conclusion/Summary : Not available.

13. Disposal considerations

Waste disposal : The generation of waste should be avoided or minimized wherever possible. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe way. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Disposal should be in accordance with applicable regional, national and local laws and regulations.

Refer to Section 7: HANDLING AND STORAGE and Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION for additional handling information and protection of employees.

14 . Transport information

Regulatory information	UN number	Proper shipping name	Classes	PG*	Label	Additional information
DOT Classification	UN1993	FLAMMABLE LIQUID, N.O.S. (Contains: Methanol)	3	III		-
TDG Classification	UN1993	FLAMMABLE LIQUID, N.O.S. (Contains: Methanol)	3	III		-
IMDG Class	UN1993	FLAMMABLE LIQUID, N.O.S. (Contains: Methanol)	3	III		-
IATA-DGR Class	UN1993	FLAMMABLE LIQUID, N.O.S. (Contains: Methanol)	3	III		-

PG* : Packing group

DOT Reportable Quantity	Methanol, 2733 gal of this product.
Marine pollutant	Not applicable.

North-America NAERG : 128

15 . Regulatory information

HCS Classification : Flammable liquid
Toxic material
Irritating material
Target organ effects

U.S. Federal regulations : **United States inventory (TSCA 8b)**: All components are listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Methanol
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: NE-900: Fire hazard, Immediate (acute) health hazard, Delayed (chronic) health hazard

CERCLA: Hazardous substances.: Methanol: 5000 lbs. (2270 kg);

Clean Water Act (CWA) 307: No products were found.

Clean Water Act (CWA) 311: No products were found.

Clean Air Act (CAA) 112 regulated flammable substances: No products were found.

Clean Air Act (CAA) 112 regulated toxic substances: No products were found.

Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs) :

Listed

SARA 313

		Product name	CAS number	Concentration
Supplier notification	:	Methanol	67-56-1	10 - 30

United States inventory (TSCA 8b) : All components are listed or exempted.

Canada

WHMIS (Canada) : Class B-2: Flammable liquid
Class D-1B: Material causing immediate and serious toxic effects (Toxic).
Class D-2A: Material causing other toxic effects (Very toxic).
Class D-2B: Material causing other toxic effects (Toxic).

Canada (CEPA DSL): : All components are listed or exempted.

16 . Other information

Label requirements : FLAMMABLE LIQUID AND VAPOR. HARMFUL IF INHALED, ABSORBED THROUGH SKIN OR SWALLOWED. INHALATION CAUSES HEADACHES, DIZZINESS, DROWSINESS AND NAUSEA AND MAY LEAD TO UNCONSCIOUSNESS. CAUSES RESPIRATORY TRACT, EYE AND SKIN IRRITATION. MAY CAUSE BLINDNESS IF SWALLOWED. PROLONGED OR REPEATED CONTACT MAY DRY SKIN AND CAUSE IRRITATION. CONTAINS MATERIAL THAT MAY CAUSE TARGET ORGAN DAMAGE, BASED ON ANIMAL DATA. POSSIBLE BIRTH DEFECT HAZARD - CONTAINS MATERIAL WHICH MAY CAUSE BIRTH DEFECTS, BASED ON ANIMAL DATA. POSSIBLE DEVELOPMENTAL HAZARD - CONTAINS MATERIAL WHICH MAY CAUSE ADVERSE DEVELOPMENTAL EFFECTS, BASED ON ANIMAL DATA.

Hazardous Material Information System (U.S.A.) :

Health	☐	3
Flammability		3
Physical hazards		0
Personal protection		g

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on MSDSs under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

16 . Other information

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.) :

Date of printing : 12/5/2011.

◸ Indicates information that has changed from previously issued version.

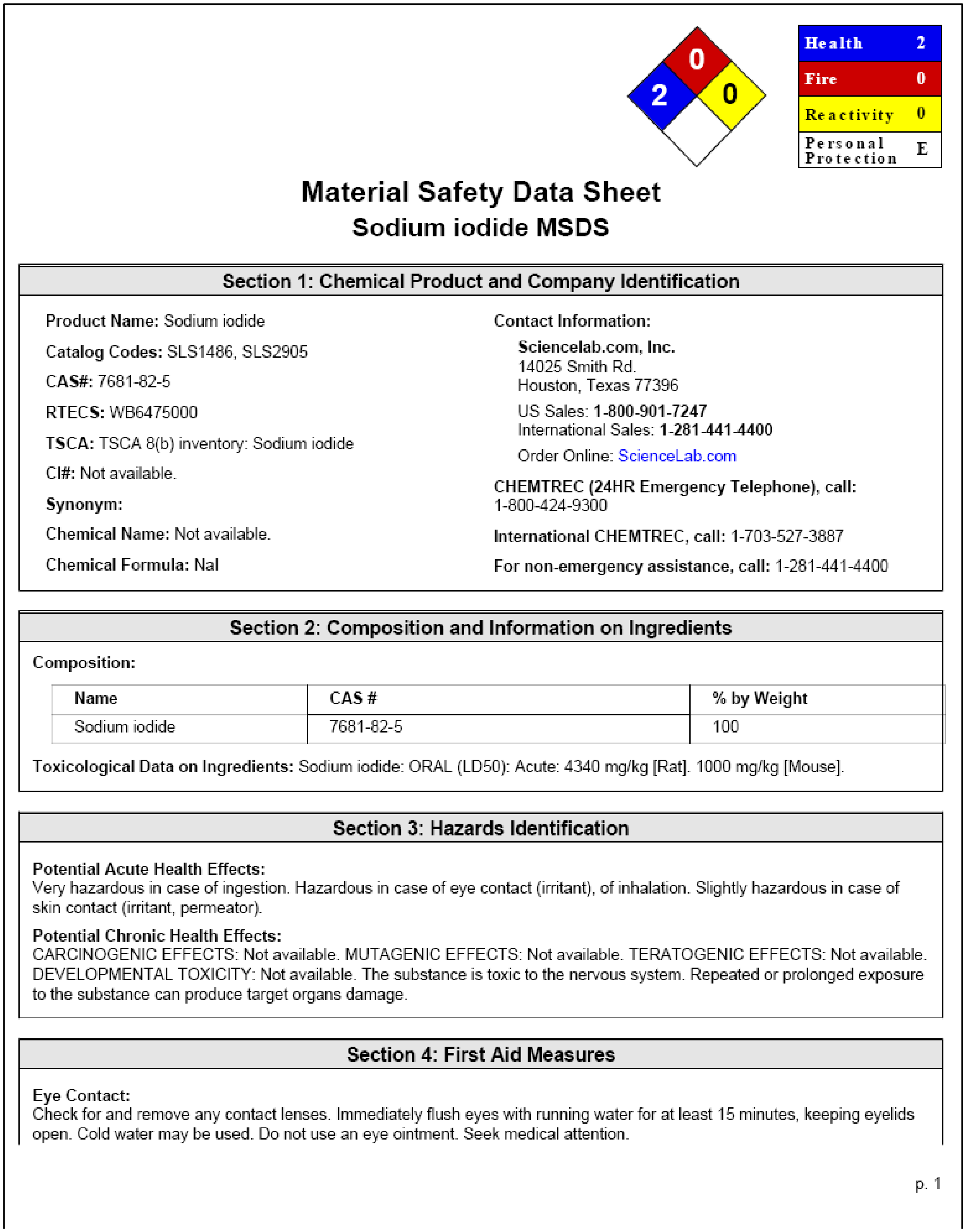
Notice to reader

NOTE: The information on this MSDS is based on data which is considered to be accurate. Baker Hughes, however, makes no guarantees or warranty, either expressed or implied of the accuracy or completeness of this information.

The conditions or methods of handling, storage, use and disposal of the product are beyond our control and may be beyond our knowledge. For this and other reasons, we do not assume responsibility and expressly disclaim liability for loss, damage or expense arising out of or in any way connected with the handling, storage, use or disposal of this product.

This MSDS was prepared and is to be used for this product. If the product is used as a component in another product, this MSDS information may not be applicable.

A-6 Sodium Iodide MSDS



Health	2
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet

Sodium iodide MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium iodide

Catalog Codes: SLS1486, SLS2905

CAS#: 7681-82-5

RTECS: WB6475000

TSCA: TSCA 8(b) inventory: Sodium iodide

CI#: Not available.

Synonym:

Chemical Name: Not available.

Chemical Formula: NaI

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium iodide	7681-82-5	100

Toxicological Data on Ingredients: Sodium iodide: ORAL (LD50): Acute: 4340 mg/kg [Rat]. 1000 mg/kg [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of ingestion. Hazardous in case of eye contact (irritant), of inhalation. Slightly hazardous in case of skin contact (irritant, permeator).

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to the nervous system. Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

p. 1

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention.

Serious Skin Contact: Not available.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Examine the lips and mouth to ascertain whether the tissues are damaged, a possible indication that the toxic material was ingested; the absence of such signs, however, is not conclusive. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Do not ingest. Do not breathe dust. Avoid contact with eyes Wear suitable protective clothing In case of insufficient ventilation, wear suitable respiratory equipment If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents, metals, acids.

Storage:
No specific storage is required. Use shelves or cabinets sturdy enough to bear the weight of the chemicals. Be sure that it is not necessary to strain to reach materials, and that shelves are not overloaded.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Deliquescent crystals solid.)

Odor: Odorless.

Taste: Bitter. Saline. (Strong.)

Molecular Weight: 149.89 g/mole

Color: White.

pH (1% soln/water): 7 [Neutral.]

Boiling Point: Decomposes.

Melting Point: 651°C (1203.8°F)

Critical Temperature: Not available.

Specific Gravity: 3.67 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, methanol, acetone.

Solubility:
Easily soluble in cold water, hot water. Partially soluble in methanol, acetone.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances:

Highly reactive with oxidizing agents, acids. Reactive with metals.

Corrosivity:
Highly corrosive in presence of aluminum, of zinc, of copper. Corrosive in presence of steel. Non-corrosive in presence of glass, of stainless steel(304), of stainless steel(316).

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact. Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 1000 mg/kg [Mouse].

Chronic Effects on Humans: The substance is toxic to the nervous system.

Other Toxic Effects on Humans:
Very hazardous in case of ingestion. Hazardous in case of inhalation. Slightly hazardous in case of skin contact (irritant, permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Sodium iodide

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC): R36- Irritating to eyes.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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