Canadian Gas Treating Solvent Quality Control – Unique Challenges

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ABSTRACT

Unusual gas compositions, harsh weather conditions, and remote producing locations have posed significant problems for the Canadian Gas Treating Industry. A few amine types, including DEA, MDEA, and Sulfinol-D™ are widely used in Canadian gas treating facilities. Process conditions cause these amines to degrade over time, with each amine type producing a unique set of degradation products. The most common of these degradation products are discussed, as are their potential effects on gas treating performance. The importance of controlling *total solvent quality*, rather than just controlling Heat Stable Salt levels, is addressed. Canadian reclaiming case studies are used to explore removal of undesirable compounds from selected solvents.

INTRODUCTION

The Canadian Gas Processing Industry is recognized the world over for its expertise in gas treating and sulfur recovery. This expertise has been achieved by meeting the unusual challenges encountered in the region. Extremely sour gas, distinctive H_2S/CO_2 ratios, remote locations, harsh weather conditions, and stringent environmental regulations are among the hurdles that have been overcome by Canadian gas processors.

In this paper, we will look at the gas treating solvents that, because of their particular features and benefits, are commonly used in the region. Gas treating plant operators are well aware of the potential problems posed by the gradual accumulation of Heat Stable Salts (HSS) that commonly occurs in virtually all amine systems. There is less of an awareness, however, of other types of amine system contaminants and their potential effects on plant operations. We will examine degradation products found in each of the solvents in common use in Canada; a topic that has received little attention in the literature. The importance of monitoring and controlling *total solvent quality*, as opposed to monitoring and controlling only HSS, will be explored.

Of course, once the operator becomes aware of all of the undesirable components that may be in an amine solution and of the problems that may result from them being there, the obvious question is “how do I get them out of my amine solution?” This paper presents reclaiming case studies from Canadian gas plants that demonstrate the effectiveness of removing degradation products from selected solvents using vacuum distillation.

SOLVENT CHOICE DRIVEN BY GAS COMPOSITION

Solvent selection for gas treating applications is typically driven by the inlet gas composition and treated gas specifications. H_2S, CO_2, Carbonyl Sulfide (COS), and mercaptans are the constituents in the gas that generally govern solvent selection. However, other considerations that must be taken into account when selecting a gas treating solvent include hydrocarbon solubility, special degradation considerations (e.g. if there is oxygen in the gas) and ease of reclaiming to remove potential degradation products. Solvents commonly employed in the industry are; MEA, DGA®, DEA, DIPA, MDEA, formulated MDEA solvents, Sulfinol-M™, and Sulfinol-D™. Just as each of these solvents has unique gas treating characteristics, each one also has unique degradation tendencies. The remainder of this paper describes common degradation products in these solvents, and uses Canadian reclaiming case studies to address removal of the undesirable compounds.

CONTAMINANTS AND DEGRADATION PRODUCTS - DEFINED

Heat Stable Salts (HSS) and their effects on amine system performance have been addressed extensively in the literature and are well understood by the gas treating community. HSS are not the only undesirable constituents that may be present in an amine solution, however. Rather than focusing on HSS, we will look at the other undesirable constituents and at the total level of all undesirable components (including HSS) in a solution. We will refer to the total level of contaminants and degradation products in the solution as the ***residue*** of the solution. The residue is comprised of material that is generally not considered part of a healthy gas treating solution; i.e. anything that is not free (active) amine or water. This residue, as equation 1 shows, is easy to calculate and encompasses all of the contaminants and degradation products present in the sample.

$$\text{Wt\% Residue} = 100 - \text{Wt\% Free Amine} - \text{Wt\% Water} \quad (1)$$

The residue is the total level of contaminants and degradation products present in the sample. Contaminants and Degradation Products may be defined as follows:

Contaminants

Contaminants are items that enter the process and "pollute" the amine. These items would generally include solids/particulates, hydrocarbon, process chemicals, strong cations (sodium), and HSS (from their precursors entering with the gas).[1]

Degradation Products

Degradation Products are contaminants in solution that are derived from reactions with the base amine molecule itself, where the molecule is broken down or changes chemical form. Many of these compounds are the result of irreversible degradation of the base amine molecule; ethylenediamine derivatives (THEED in the case of DEA and HEEU in the case of MEA) would be examples of this. Some of these compounds are the results of a reversible reaction or chemical equilibrium with the base amine molecule; formamides in the case of primary and secondary amines and BHEEU in the case of DGA® would be examples of this.

For optimized unit operations, it is important to know and understand the total level of residue including all contaminants and degradation products. It is also important to understand the effects of this residue on unit operations and on corrosion rates to provide a basis for evaluating reclaiming options.

AMINE SPECIFIC DEGRADATION PRODUCT ANALYSIS

While Heat Stable Salts (HSS) are common to all amine solvents, degradation products are solvent-specific. [2,8,15,16] A description of common degradation products found in various gas treating solvents follows.

MEA

1. Formamides

N-formyl amines (formamides) are degradation products generally found in gas treating solutions that are based on primary and secondary amines.[3] Under certain conditions primary and secondary amines react with the formic acid in solution (via dehydration) to form n-formyl amines.

The data from process solutions containing formate as a HSS anion show that the following equilibrium relationship exists in the solution between the formate HSS and the n-formyl MEA (MEA-F).[4]

$$\text{Formic Acid} + \text{MEA} \Leftrightarrow \text{MEA-F} + \text{Water} \quad (2)$$

Since the above equation represents equilibrium, it is also possible to hydrolyze MEA-F back into MEA and formic acid. The heat and water present in the stripper of the amine unit will generate a new equilibrium if removing one of the above components disturbs the balance of the equation.

2. HEED

Hydroxyethylethylenediamine (HEED) is a well-known degradation product of MEA from reactions with CO_2. There is a wealth of literature on the reaction mechanisms and the corrosive nature of HEED.[1] While much of the literature has focused on MEA in CO_2 service only, HEED has been found in many combined systems treating H_2S and CO_2.

3. HEEU

Hydroxyethylethyleneurea (HEEU) is a degradation product of MEA that is not that well known since most of the literature has focused on degradation in CO_2 service. HEEU is formed via the same reaction pathway as HEED when COS is present in the gas.[6]

4. Polymers

We generally find polymers when HEED is present in MEA systems treating H_2S and CO_2. These polymers are formed from the reaction of HEED with MEA molecules to make longer chained ethylenediamines.[7]

DGA®

1. Formamides

Same as MEA above.

2. BHEEU

N,N bis(hydroxyethoxy-ethyl)urea (BHEEU) is an inert degradation product formed in the presence of COS and CO_2.[6] Formation of BHEEU can be reversed by thermal reclaiming.

3. Morpholine

This is an inert degradation product that, while rare, can occur when the solution is subjected to high temperatures.[5]

DEA

1. Formamides

Same as MEA above.

2. THEED

Tris-hydroxyethyl ethylenediamine (THEED) is a well-known degradation product of DEA from reactions with CO_2. There is a wealth of literature on the reaction mechanisms and the corrosive nature of THEED.[1,6] While much of the literature has focused on DEA in CO_2 service only, THEED has been found in combined systems treating H_2S and CO_2.

3. Bis-HEP

Bis-hydroxyethyl piperazine (bis-HEP) is a well-known degradation product of DEA from reactions with CO_2. There is a wealth of literature on the reaction mechanisms of bis-HEP.[1,6] While much of the literature has focused on DEA in CO_2 service only, bis-HEP has been found in combined systems treating H_2S and CO_2.

4. MEA

In the presence of certain chemical compounds (oxygen) or intermediates, it is possible to degrade or break down the DEA molecule to simpler amines. Monoethanolamine (MEA) is one of the simpler amines that may be formed from DEA degradation. It is important to monitor the level of MEA in the circulating DEA system due to Amine Stress Corrosion Cracking (ASSC) concerns associated with MEA. MEA will also generally further degrade in the system leading to concerns with the compounds reviewed above.

5. Bicine

Bis-(hydroxyethyl) glycine (Bicine) is a degradation product formed in the presence of DEA and unstable chemical intermediates, and is considered corrosive.[8,17]

6. Polymers

We generally find polymers when THEED is present in DEA systems treating H_2S and CO_2. These polymers are formed from the reaction of THEED with DEA molecules to make longer chained ethylenediamines.[7]

DIPA

1. Formamides

Same as MEA above.

2. DIPA-OX

Hydroxypropylmethyloxazolidone (HPMO or DIPA-OX) is a well-known degradation product of DIPA from reactions with CO_2. There is a wealth of literature on the reaction mechanism of DIPA-OX.[1,6,10] The literature also states that DIPA-OX is the endpoint of DIPA degradation in CO_2 service (due to steric hindrance), so polymers of DIPA are not *supposed* to be formed like they are with MEA and DEA.

MDEA

1. MDEA Fragments

MDEA in Tail Gas Treating units (TGTU), Acid Gas Enrichment units (AGE), and in some main amine systems should be monitored for MDEA fragments. These include MMEA, DEA, Bicine and C2+ HSS anions.[9] It is also important to note that as ethanolamines (from MDEA degradation) accumulate in the solvent, they will generally undergo further degradation to compounds listed in the above sections. The presence of these primary and secondary amines may affect the gas treating selectivity of the amine solution.

2. Special Considerations For Formulated MDEA

Depending upon the formulating agent, MDEA may need to be monitored for degradation products for the ethanolamines listed above. We recommend discussing this with your amine supplier if operating problems are experienced, or if analytical results indicate low sample recovery (large amounts of unidentified components).

Sulfinol-D™

1. Formamides

Same as MEA above.

2. DIPA-OX

Same as DIPA above.

3. Dimers

The literature states that steric hindrance prevents further degradation of DIPA-OX to diamines (“dimers”). However, we generally do find dimers in Sulfinol-D systems treating H_2S and CO_2. These “dimers” are similar to the diamines found in MEA and DEA systems, and are likely formed via the same pathway.

4. Polymers

We generally find polymers when dimers are present in systems treating H_2S and CO_2 utilizing Sulfinol-D. These polymers are formed by the reaction of a dimer with a DIPA molecule (analogous to diamines of MEA and DEA reacting further to make longer chained ethylenediamines).

5. MIPA

In the presence of certain chemical compounds (oxygen) or intermediates, it is possible to degrade or break down the DIPA molecule to simpler amines. Monoisopropanolamine (MIPA) is one of the simpler amines that may be formed from DIPA degradation.

6. TIPA

Triisopropanolamine (TIPA) may be found in systems treating H_2S and CO_2 utilizing Sulfinol-D, when evidence of oxygen degradation is present. Literature shows that when amines degrade they generally form simpler amines, but sometimes these simpler amines react with the base amine molecule (or others) to form a more complex amine.[11]

7. Others

Since Sulfinol-D™ is a formulation of DIPA and 1,1-Dioxidetetrahydrothiophene (Sulfolane), we typically find other degradation products in the solution that are attributable to the degradation of sulfolane when oxygen is present in the treated gas. These compounds are also generally considered corrosive.[10,12,13]

Sulfinol-M™

1. MDEA Fragments

As with MDEA in Tail Gas Treating units (TGTU), Acid Gas Enrichment units (AGE), and in some main amine system service, Sulfinol-M should be monitored for MDEA fragments. These include MMEA, DEA, Bicine and C2+ HSS anions.[9] It is important to note that as ethanolamines (from MDEA degradation) accumulate in the solvent, they will generally undergo further degradation to compounds listed in the above sections. The presence of these primary and secondary amines may also affect the gas treating selectivity of the amine solution.

2. Others

Since Sulfinol-M™ is a formulation of MDEA and 1,1-Dioxidetetrahydrothiophene (Sulfolane), we typically find other degradation products in the solution that are attributable to the degradation of sulfolane when oxygen is present in the treated gas. These compounds are also generally considered corrosive. [10,12,13]

IMPORTANCE OF AMINE BALANCE

It is very important to calculate and understand the amine balance from the complete analysis of the circulating solvent. This practice will allow you to check the completeness of the sample analysis and to characterize some of the unknown compounds in the solution. The amine balance may indicate a need for further analysis or it may provide clues to explain operational issues.[18]

Excess Amine

An amine balance takes the measured amine strength (alkalinity) and subtracts the actual amount of the desired amine type present in solution (the amine specifically identified by more sophisticated analytical techniques). In DEA systems, for example, you will take the measured (titrated) amine strength and subtract out the identified (by GC) DEA in the sample. The excess amine is material that has base strength, but is not a DEA molecule. Certain degradation products of DEA (THEED and Bis-HEP) have base strength but do not perform as well as DEA in removing acid gas.[7] (THEED is also considered corrosive, so there are additional concerns with it.) When reclaiming DEA systems these degradation products are removed, thus reducing the titrated base strength of the solvent. If the concept of excess amine is not well understood, this reduction in base strength may be incorrectly interpreted as a loss of DEA. In reality, degradation products with base strength have been removed while the *actual* DEA strength of the solution has not changed.

Specific Example – Sulfinol-D

Table 1 shows a partial solvent analysis from a Sulfinol-D™ solution. We can see that the alkalinity of the sample (titrated base strength) is approximately 36 wt%. More detailed analysis shows that MIPA, DIPA, and Dimers (diamines) are the individual species contributing to the total base strength. Approximately 26.9 wt% DIPA, the desired amine type, is present in the sample. About 4.4 wt% MIPA (resulting from DIPA degradation caused by levels of oxygen in the feed gas ranging from 10 to 100 ppm) is also present in the sample. MIPA will participate in acid gas removal, and will not be removed by vacuum distillation in a single pass. Another 4.7 wt% of the solution is “Dimers”, which are undesirable degradation product that will be removed by vacuum distillation. The removal of the Dimers during reclaiming will result in a reduction in titrated base strength of 4.7 wt%. It is important to note that this drop in base strength is due to degradation product removal and not due to loss of useful amine, because some plant operators have claimed large solvent losses when Sulfinol-D™ has been reclaimed.[12] We can see from this example that the pre-reclaiming DIPA level could be perceived to be higher than it actually is because of the presence of degradation products possessing base strength. This an important phenomenon to understand when planning for and evaluating the results of a reclaiming job.

Table 1

Base Strength (alkalinity)	**36 Wt%**
MIPA, wt%	4.4
DIPA, wt%	26.9
Dimers, wt%	4.7
Total, wt%	36.0
Excess Base vs. DIPA/MIPA	*4.7*
Perceived DIPA Loss	***4.7***

CASE STUDIES

The following three case studies show some interesting solvent quality control challenges.

Gas Plant Utilizing Sulfinol-D

A gas plant utilizing Sulfinol-D was experiencing corrosion and some operational issues caused by high solvent viscosity. Since the level of HSS in the solution was not particularly high, the plant operator decided to look at other compounds in the solution that could be contributing to the corrosion and viscosity concerns. The sample analysis of the original solution (Feed) is listed in Table 2. These data show that there were significant levels of Dimers (6.48 wt%) and Others (from Sulfolane degradation) (3.74 wt%). The operator concluded that both of these compounds could potentially be increasing the corrosive nature of the solvent, and could be affecting the viscosity by displacing water from the solution.[14] The operator also concluded that these compounds were the result of oxygen contamination in the gas being treated.

The operator wanted to remove as much of the contamination as possible using CCR’s vacuum distillation in a batch (once-through) mode. The results reported by CCR’s contracted lab are listed in Table 2. The operator contracted a different third party laboratory to analyze the baseline sample and the final product to verify the reclaiming results, and these data may be found in Table 3.

Table 2

Sample Analysis Before And After Single Pass Through Vacuum Distillation Unit

	Feed	**Product**	**Removal**
Strong Acid Anions, wt%	0.39	0.02	96%
Strong Cations, wt%	0.11	0.00	98%
DIPA-OX, wt%	4.52	1.09	76%
Dimers, wt%	6.48	0.00	99+%
TIPA, wt%	1.17	0.51	57%
Other, wt%	3.74	0.92	75%
Total Residue, wt%	16.76	2.56	85%

Both sets of data show good contaminant removal on a batch basis through the vacuum distillation unit. The operational parameters of the vacuum distillation unit were improved during the course of the job with the final analytical results verifying the effectiveness of the unit optimization. In particular it should be noted that the DIPA-OX removal efficiency improved as the job progressed. (Because the boiling points of DIPA and DIPA-OX are fairly close together, DIPA-OX is more difficult to remove by distillation than most other common degradation products. Therefore, a high removal efficiency of DIPA-OX is a good indicator that the CCR equipment operating parameters are optimized). While some plants utilizing Sulfinol-D™ employ their own reclaimers, many find them troublesome and a source of high DIPA losses. The literature gives specific operating requirements for “conventional” reclaiming of DIPA-OX as 50 mm Hg, 350 °F, utilizing 14 trays with direct steam sparging. It is easy to see why this unit operation may be quite troublesome, and why mobile vacuum distillation technology may be a preferable alternative.[6] The apparent low removal efficiency of TIPA (Table 2) is explained by the relatively low repeatability of the TIPA concentration by the lab. The methodology used to analyze for TIPA can be expected to give measurement error at low levels of TIPA (<1 wt%). Since this lab is not called upon to measure TIPA very often, the cost of upgrading the analytical procedure is not economically justifiable.

Table 3
Sample Analysis For Batch Reclaiming of Sulfinol-D™

	Start	**End**	**Removal**
DIPA-OX, wt%	5.20	0.20	96%
Other, wt%	9.45	0.10	99%
Total Residue, wt%	14.65	0.30	98%

Both Table 2 and Table 3 indicate that the solvent quality was greatly improved as a result of reclaiming. After the reclaiming was complete, the plant operator experienced lower corrosion rates. Solvent viscosity was also improved, resulting in better mass and heat transfer performance.

Gas Plant Utilizing Formulated MDEA

A gas plant utilizing a formulated MDEA solvent was experiencing corrosion and some operational difficulties related to changes in the physical properties of the solvent. The level of HSS in solution concerned the plant operator and was the initial reason to look at reclaiming. However, a detailed analysis noted that there were a few other contaminants/degradation products that needed to be removed as well. See Table 4 below.

The plant operator selected an target of 500 ppm for the Bicine in solution and also wanted to remove as much of the polymeric material as possible. The operator suspected that the Bicine was due to intermittent oxygen ingress to the system via the gas being treated and that the polymers were due to degradation of their old MDEA formulation. Batch vacuum distillation reclaiming during a quick plant outage was judged to be the most efficient approach. The operator had some concerns, which proved to be unfounded, as to whether the contaminants could be removed in a single pass through the

Table 4
Sample Analysis Before And After Single Pass Through Vacuum Distillation Unit

	Feed	Product	Removal
Strong Acid Anions, wt%	1.24	<0.01	99+%
Strong Cations, wt%	0.41	<0.01	99+%
Polymers, wt%	2.27	0.13	94%
Bicine, wt%	0.29	0.05	83%
Other, wt%	0.45	<0.01	99+%
Total Residue, wt%	5.06	0.18	96%

CCR equipment. Table 4 shows that processing removed 96% of the entire residue in the system, and reduced the Bicine to the target level.

Contaminated Glycol
Glycols are used for hydrate inhibition/gas dehydration, and for heating and cooling mediums. The type of glycol used is selected based on the features and benefits that it will provide. If these glycols become contaminated, the physical properties may change to the point that the solvent is no longer capable of performing its required function.

A gas plant using a mixture of Triethylene Glycol (TEG) and water as a heat medium, experienced a gradual buildup of Ethylene Glycol (EG) in the solution. The plant operator became concerned that the amount of EG in solution (>3%) could adversely effect the performance of the heat medium, and that the EG could degrade and cause unit reliability concerns. Table 5 below supports the operator's concerns by demonstrating that there are significant differences in the physical properties of the two glycols.

Table 5
Selected Physical Properties of EG & TEG

	EG	TEG
Boiling Point, °F (at 760 mm Hg)	387.1	545.9
Approximate decomposition Temperature, °F	329	404
Heat Capacity, J/mol*K	149.8	333.7

Clearly, the performance of the heat medium solution would be expected to change as the concentration of EG increased. The operator wanted to have the EG content of the solution reduced to less that 1 percent, and wanted to do so without interrupting plant operations. "Side stream" (on-line) vacuum distillation was selected since it could meet all of the plant's requirements while ensuring that the glycol was not degraded in the reclamation process. Table 6 shows the before and after sample results from the system.

Table 6
Sample Analysis For Side Stream Reclaiming of TEG

	Start	End	Removal
Ethylene Glycol, wt%	3.2	0.8	75%

CONCLUSION

While controlling the level of Heat Stable Salts in an amine system should remain a priority for gas treating plant operators, they must also be aware of, and control, the numerous other undesirable compounds that could also be present in the amine. The practice of monitoring and controlling all of the contaminants in an amine system is known as *total solvent quality control*. Amine degradation products are commonly found in amine systems, and can cause many of the same operational problems that may be mistakenly attributed to high Heat Stable Salt levels. Each of the amine types in common use in Canadian gas treating has its own unique set of degradation products. Like Heat Stable Salts, virtually all of these degradation products can be removed by reclaiming the amine solution using vacuum distillation technology. The other commercial reclaiming technologies (ion exchange and electrodialysis) are also able to remove Heat Stable Salts, but cannot remove many of these degradation products. Thus, using ion exchange or electrodialysis technology to reclaim a solvent will often result in only part of the *total solvent quality* problem being resolved. Resolution of the entire *total solvent quality* problem can only be accomplished if reclaiming is performed using vacuum distillation technology.

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Appendix

MEA Contamination/Degradation In Combined Treating Service

HSS	Potentially Corrosive	Contaminant
Formamide (MEAF)	Non-Corrosive	Contaminant/Degradation
HEED	Potentially Corrosive	Degradation
HEEU	Non-Corrosive	Degradation
Polymeric Material	Non-Corrosive	Degradation

MEA Solvent Quality Management With Merchant Reclaiming Options
Vacuum Distillation, Ion Exchange, Electrodialysis

Control of HSS	All
Control of MEAF (Slip-Stream Processing)	All
Control of MEAF (Batch Processing)	Vacuum Distillation Only
Control of HEED	Vacuum Distillation Only
Control of HEEU	Vacuum Distillation Only
Control of Polymeric Material	Vacuum Distillation Only

Best Efficiency = Batch Processing

DGA® Contamination/Degradation In Combined Treating Service

HSS	Potentially Corrosive	Contaminant
Formamide (DGAF)	Non-Corrosive	Contaminant/Degradation
BHEEU	Non-Corrosive	Degradation (Reversible)
Polymeric Material	Non-Corrosive	Degradation

DGA® Solvent Quality Management With Merchant Reclaiming Options
Vacuum Distillation, Ion Exchange, Electrodialysis

Control of HSS	All
Control of DGAF (Slip-Stream Processing)	All
Control of DGAF (Batch Processing)	Vacuum Distillation Only
Control/Reversal of BHEEU	Vacuum Distillation Only
Control of Polymeric Material	Vacuum Distillation Only

Best Efficiency = Batch Processing

DEA Contamination/Degradation In Combined Treating Service

HSS	Potentially Corrosive	Contaminant
Formamide (DEAF)	Non-Corrosive	Contaminant/Degradation
THEED	Potentially Corrosive	Degradation
Bis-HEP	Non-Corrosive	Degradation
MEA	ASCC Concerns	Degradation
Bicine	Potentially Corrosive	Degradation
Polymeric Material	Non-Corrosive	Degradation

DEA Solvent Quality Management With Merchant Reclaiming Options
Vacuum Distillation, Ion Exchange, Electrodialysis

Control of HSS	All
Control of DEAF (Slip-Stream Processing)	All
Control of DEAF (Batch Processing)	Vacuum Distillation Only
Control of THEED	Vacuum Distillation Only
Control of bis-HEP	Vacuum Distillation Only
Control of MEA	Vacuum Distillation Only
Control of Bicine	Ion Exchange - Partial Vacuum Distillation
Control of Polymeric Material	Vacuum Distillation Only

Best Efficiency = Batch Processing

DIPA Contamination/Degradation In Combined Treating Service

HSS	Potentially Corrosive	Contaminant
Formamide (DIPAF)	Non-Corrosive	Contaminant/Degradation
DIPA-OX	Non-Corrosive	Degradation
Polymeric Material	Non-Corrosive	Degradation

DIPA Solvent Quality Management With Merchant Reclaiming Options
Vacuum Distillation, Ion Exchange, Electrodialysis

Control of HSS	All
Control of DIPAF (Slip-Stream Processing)	All
Control of DIPAF (Batch Processing)	Vacuum Distillation Only
Control of DIPA-OX (Slip-Stream Processing)	All
Control of DIPA-OX (Batch Processing)	Vacuum Distillation Only
Control of Polymeric Material	Vacuum Distillation Only

Best Efficiency = Batch Processing

MDEA Contamination/Degradation In TGTU, AGE, and Combined Treating Service

HSS	Potentially Corrosive	Contaminant
MMEA	Non-Corrosive	Degradation
DEA	Non-Corrosive	Degradation
Bicine	Corrosive	Degradation
HE-Sarcosine	Corrosive	Degradation
Polymeric Material	Non-Corrosive	Degradation

MDEA Solvent Quality Management With Merchant Reclaiming Options
Vacuum Distillation, Ion Exchange, Electrodialysis

Control of HSS	All
Control of MMEA	Vacuum Distillation Only
Control of DEA	Vacuum Distillation Only
Control of Bicine	Ion Exchange - Partial Vacuum Distillation
Control of HE-Sarcosine	Ion Exchange - Partial Vacuum Distillation
Control of Polymeric Material	Vacuum Distillation Only

Best Efficiency = Batch Processing

Formulated MDEA Contamination/Degradation In Refinery Service
Special considerations based on formulation. The compounds measured in the residue will generally be listed under the various amine listed above to aide in the evaluation.

Sulfinol-D Contamination/Degradation In Combined Treating Service

HSS	Potentially Corrosive	Contaminant
Formamide (DIPAF)	Non-Corrosive	Contaminant/Degradation
DIPA-OX	Non-Corrosive	Degradation
Dimers	Potentially Corrosive	Degradation
Polymeric Material	Non-Corrosive	Degradation
TIPA	Non-Corrosive	Degradation
Others (From Sulfolane)	Potentially Corrosive	Degradation

Sulfinol-D Solvent Quality Management With Merchant Reclaiming Options
Vacuum Distillation, Ion Exchange, Electrodialysis

Control of HSS	All
Control of DIPAF (Slip-Stream Processing)	All
Control of DIPAF (Batch Processing)	Vacuum Distillation Only
Control of DIPA-OX (Slip-Stream Processing)	All
Control of DIPA-OX (Batch Processing)	Vacuum Distillation Only
Control of Dimers	Vacuum Distillation Only
Control of Polymeric Material	Vacuum Distillation Only
Control of TIPA	Vacuum Distillation Only
Others (From Sulfolane)	Vacuum Distillation Only

Best Efficiency = Batch Processing

Sulfinol-M Contamination/Degradation In Combined Treating Service

HSS	Potentially Corrosive	Contaminant
MMEA	Non-Corrosive	Degradation
DEA	Non-Corrosive	Degradation
Bicine	Corrosive	Degradation
HE-Sarcosine	Corrosive	Degradation
Polymeric Material	Non-Corrosive	Degradation
Others (From Sulfolane)	Potentially Corrosive	Degradation

Sulfinol-M Solvent Quality Management With Merchant Reclaiming Options
Vacuum Distillation, Ion Exchange, Electrodialysis

Control of HSS	All
Control of MMEA	Vacuum Distillation Only
Control of DEA	Vacuum Distillation Only
Control of Bicine	Ion Exchange - Partial Vacuum Distillation
Control of HE-Sarcosine	Ion Exchange - Partial Vacuum Distillation
Control of Polymeric Material	Vacuum Distillation Only
Others (From Sulfolane)	Vacuum Distillation Only

Best Efficiency = Batch Processing