Ammonia-nitrogen (NH$_3$-N) pollutant can be detected in many kinds of industrial wastewater. Considering ammonia has a very high oxygen demand and is highly toxic for aquatic ecosystem, Taiwan Environmental Protection Administration has added the NH$_3$-N criteria in Effluent Standards since 2011. Currently, the NH$_3$-N concentration in the effluent from various kinds of industries must be under 20 mg/L.

The production of coke would produce the coking wastewater, whose NH$_3$-N concentration is about 500 to 1000 mg/L. Dragon Steel Corporation (DSC) is an integrated steel plant with an annual production capacity up to six million tons of crude steel and two million tons of coke. To comply with the NH$_3$-N criteria, DSC has submitted the NH$_3$-N pollutant reduction plan in March 2014 and received the approval by the local authority. The plan has been successfully completed in October 2017. At present, the NH$_3$-N concentration in DSC’s effluent is steadily less than 20 mg/L.

This article would introduce the public policy-making process for NH$_3$-N criteria in Taiwan and how DSC reacts to comply with the standard. The action of DSC includes three parts. First, DSC has evaluated several possible solutions for NH$_3$-N removal from wastewater. Second, DSC has added the ammonia removal facilities in by-product plant to reduce NH$_3$-N pollutant in coking wastewater. Third, DSC has improved nitrification reaction in activated sludge system, and built a backup system for abnormal ammonia wastewater.

Keywords: Wastewater Treatment, Ammonia, Coking Wastewater, Nitrification

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** Manager of Environmental Protection Department, Dragon Steel Corporation, Taichung, Taiwan
1. Introduction
Ammonia-nitrogen (NH$_3$-N), including free ammonia (NH$_3$) and ammonium ion (NH$_4^+$), is the main nitrogen pollutants in water environment. Water rich in ammonia-nitrogen can cause eutrophication, increased algal blooms, decreased DO, toxicity to aquatic organisms, and lead to deterioration in water quality. Since 2003, Taiwan EPA has implemented several investigation to monitor the NH$_3$-N concentration in most rivers. In Taiwan, the NH$_3$-N concentration in the clean rivers should be under 0.5 mg/L. However, the investigation from 2003 to 2009 shows that there is less than 50% of rivers whose water quality can meet the standard. To ameliorate this problem, a strict NH$_3$-N standard has been announced by Taiwan EPA since 2011.

Three major river pollution sources in Taiwan are household, industrial and livestock wastewater. According to the studies of EPA, there is about 160 thousand kilogram of NH$_3$-N being discharged into Taiwan’s rivers every day. About 30% of discharged NH$_3$-N is made by industrial wastewater. The top three sources of industrial ammonia wastewater, which accounts for 70% of total industrial contribution, are the effluent from science parks, petrochemical industry, and chemical industry. Those industries need to apply the nitrogen-containing chemicals or material in production, which leads to high concentration of NH$_3$-N in the effluent.

To restrict the ammonia wastewater from those industries, Taiwan EPA has formulated the effluent standards of NH$_3$-N for the science parks, petrochemical industry, and chemical industry respectively in October 2012, December 2011, and January 2014. The standards (shown in table 1-1) differ between the new and existing enterprise in different industries. The effluent limitation of NH$_3$-N for all kinds of new enterprises has been set at 20 mg/L, and comes into effect from the date of promulgation. Considering the engineering feasibility, EPA allows the existing enterprises to modify their facilities to meet the standard within the deadline. For example, the NH$_3$-N limitation for existing chemical manufacturing enterprise without high nitrogen process is 20 mg/L since July 2014. If some enterprise needs time to carry out its improvements to comply with the NH$_3$-N standards, it could submit an effluent pollutant reduction plan to EPA. If plan is approved, the NH$_3$-N standard enforcement for the enterprise could be postponed to 1$^{st}$ January 2018.

Compared to ammonia, nitrate nitrogen pollutant has less negative effect on aquatic environment, the effluent standard of nitrate nitrogen for all enterprise is 50 mg/L.
<table>
<thead>
<tr>
<th>Applicable Scope</th>
<th>Effluent Limitation (mg/L)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrate Nitrogen</td>
<td>Ammonia Nitrogen</td>
</tr>
<tr>
<td>Science Park</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petrochemical Industry</td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>60</td>
<td></td>
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<td></td>
<td></td>
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<td>20</td>
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<td>60</td>
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<tr>
<td></td>
<td>20</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Enterprise</td>
<td>50</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: All industries located on water protection zone must discharge the effluent containing total nitrogen concentration under 15 mg/L.
2. NH$_3$-N Pollutant Reduction Plan of DSC

2.1 Estimation of Possible Solutions for NH$_3$-N Removal

Dragon Steel Corporation (DSC) is an integrated steel plant with an annual production capacity up to six million tons of crude steel and two million tons of coke. Since the coke oven plant and by-product plant belong to chemical industry, DSC must comply with Chemical Industry Effluent Standards announced by Taiwan EPA in January 2014. The coking wastewater from DSC contains high NH$_3$-N concentration, which leads to the NH$_3$-N concentration (about 100 mg/L) in the effluent higher than the legal standard (20 mg/L). To reduce the NH$_3$-N pollutant in wastewater, DSC has estimated several solutions for ammonia wastewater treatment. Many methods are commonly used for the treatment of ammonia wastewater in Taiwan. The following are some example.

(1) Air stripping

Air stripping is a process by which liquid is brought into intimate contact with gas, so that some undesirable substances present in liquid can be carried away by the gas. NH$_3$-N exists as both the dissolved gas form (NH$_3$) and ionized form (NH$_4^+$, ammonium) in water. These two species are present in a dynamic equilibrium according to the following equation:

$$\text{NH}_3 + \text{H}_2\text{O} \leftrightarrow \text{NH}_4^+ + \text{OH}^-$$

Below pH 7 of water, virtually all NH$_3$-N will be present as ammonium. Above pH 12 of water, virtually all NH$_3$-N will be present as a dissolved gas. In the range between 7 and 12, both ammonium and dissolved ammonia gas would exist together. Percentage of dissolved ammonia gas would increase with increasing pH of water. The higher pH value, the higher proportion of NH$_3$. In ammonia stripping process, the pH of wastewater would be adjusted to about 11, and air, which is pumped to the bottom of the wastewater from fan, would travel upward to strip away the dissolved ammonia gas in the water. The removed ammonia gas can be properly disposed by air pollution control facility.

(2) Chemical precipitation method (MAP Precipitation)

Chemical precipitation method intends to reduce the water solubility of ammonia by the formation of indissoluble salt which can be separated by sedimentation. NH$_3$-N in wastewater can be removed by MAP precipitation method, in which precipitant Mg$^2+$ and PO$_4^{3-}$ reacts with NH$_4^+$ in wastewater to generate precipitate in the form of complex salt NH$_4$MgPO$_4$$\cdot$6H$_2$O (known as struvite or magnesium ammonium phosphate (MAP).) The reaction is expressed below:

$$\text{Mg}^2^+ + \text{PO}_4^{3-} + \text{NH}_4^+ + 6\text{H}_2\text{O} \rightarrow \text{MgNH}_4\text{PO}_4$$

$\cdot$6H$_2$O↓
The MAP precipitation has short reaction time and simple process. It is suitable for the treatment of high-concentration NH$_3$-N wastewater. But, the addition of various chemicals (like phosphoric acid and magnesium source) is very costly.

(3) Biological nitrification-denitrification process
Under aerobic condition, the ammonia can be biologically converted to nitrate (NO$_3^-$) by nitrifying bacteria in the process of nitrification. Under an anoxic (lacking dissolved oxygen) or anaerobic (in the absence of free oxygen) condition, nitrate can be biologically converted to nitrogen gas (N$_2$) and removed from the wastewater in the process of denitrification, which is performed by denitrifying bacteria. Many biological treatments for ammonia removal is to build a suitable environment for the growth of nitrifying bacterial and denitrifying bacterial and lead to the nitrification-denitrification process. The nitrification-denitrification reaction is as below.

\[
\text{NH}_3 + \text{O}_2 \rightarrow \text{NO}_3^- \quad \text{(nitrification)}
\]

\[
\text{NO}_3^- + \text{Unoxidized organic matter} \rightarrow \text{oxidized organic matter} + \text{N}_2 \quad \text{(denitrification)}
\]

A popular example of nitrification-denitrification process is Anoxic/Oxic (A/O) system (shown in figure 2-1). The influent wastewater serves as the carbon source for bacteria, return activated sludge from the clarifier provides microorganisms. The effluent from aeration basin (the nitrate-rich water) would be pumped to mix with influent wastewater and return sludge in the anoxic basin. The denitrifying bacteria in anoxic zone could utilize the nitrate as an oxygen source and release nitrogen gas. In aerobic zone, the nitrifying bacteria could convert ammonia to nitrate. Generally, the nitrogen removal in A/O process could reach about 50%. Ideally, with high recirculation and efficient denitrification in anoxic zone, the nitrogen removal rate may reach 80%.

![Figure 2-1 Anoxic/Oxic (A/O) process](image)

---

5
2.2 Decision to Reduce Ammonia Pollution

After comparing possible technology and economic cost, DSC has completed the NH₃-N pollutant reduction plan to reduce the effluent NH₃-N concentration to less than the limitation (20mg/L). The plan includes the removal of NH₃-N from coking wastewater, enhanced nitrification in activated sludge system and installation of buffer basin and stripping equipment as the backup system. The main reasons for the decision are explained below:

(1) The NH₃-N pollutant entering wastewater treatment system is mainly from coking wastewater, whose NH₃-N concentration is about 500 to 1000 mg/L. It would be very costly to treat this kind of ammonia wastewater by chemical treatment process (like air stripping).

(2) It is very difficult to operate a biological treatment system to treat the high concentration and fluctuation of ammonia wastewater. Some bacteria are very sensitive to some parameter in environment. If the population of nitrifying or denitrifying bacteria is harmed due to an unexpected condition (like lower pH or abundant inhibitors), the nitrification/denitrification efficiency would become lower and wouldn’t be recovered immediately. That might lead to a violation of effluent standard.

(3) The by-product plant (where the coking wastewater is produced) in DSC was just constructed in 2011. There is a spare room to install the improved facilities in the by-product plant.

(4) As long as both the improved facilities in by-product plant and nitrification in activated sludge system work normally, the NH₃-N concentration in the effluent would be low enough to meet the legal standard. In case of the abnormal cases, a backup system of buffer basin and stripping equipment would be built.

3. Introduction of By-Product Plant

3.1 Source of Ammonia Wastewater in DSC

Coke is an important material for iron production. The coke is used as the reducing agent in blast furnace to reduce the iron ore (Fe₂O₃ or Fe₃O₄) to molten iron (Fe). The heating of coal in an oxygen-free atmosphere and high temperature (around 1000 to 1100 °C) would produce coke and coke oven gas (COG). The main constituents of COG are is shown on the table 3-1. Approximately, one ton of coke produced would generate 2~4 cubic meter of ammonia liquor. With water conservation, DSC could produce one ton of coke with only 0.3 ton of coking wastewater generated.
Table 3-1 Composition of raw COG

<table>
<thead>
<tr>
<th>constituent</th>
<th>content</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrogen (H₂)</td>
<td>39~65</td>
<td>Vol- %</td>
</tr>
<tr>
<td>Methane(CH₄)</td>
<td>20~42</td>
<td>Vol- %</td>
</tr>
<tr>
<td>carbon monoxide (CO)</td>
<td>4~7</td>
<td>Vol- %</td>
</tr>
<tr>
<td>carbon dioxide (CO₂)</td>
<td>1~3</td>
<td>Vol- %</td>
</tr>
<tr>
<td>higher hydrocarbon (CₓHᵧ)</td>
<td>2~8.5</td>
<td>Vol- %</td>
</tr>
<tr>
<td>H₂S</td>
<td>4~12</td>
<td>g/Nm³</td>
</tr>
<tr>
<td>NH₃</td>
<td>6~8</td>
<td>g/Nm³</td>
</tr>
<tr>
<td>BTX</td>
<td>20 ~ 30</td>
<td>g/Nm³</td>
</tr>
<tr>
<td>Calorific value</td>
<td>17.4~20</td>
<td>MJ/Nm³</td>
</tr>
</tbody>
</table>

3.2 COG Purification and Coking Wastewater in By-Product Plant

Since COG has a high calorific value and various components, it could be used as a fuel in other steelworks after purification in by-product plant. The COG purification would also recover some valuable product (such as tar, light oil, and sulfur) from raw COG. The figure 3-1 shows a schematic diagram of COG purification and water flow in DSC by-product plant. The three main steps of COG treatment and water flow in by-product plant are described below:

Figure 3-1 COG purification process and water flow in by-product plant

(1) Primary gas cooling/tar and liquor separation
Since the crude COG is at the temperature about 1000 °C, the first step of COG treatment is to cool it. The crude COG would first be cooled by direct contact with a re-circulated
water in downcomer spray. After water spray, the COG is led to the primary cooler. When sufficient cooling water of the right temperature is available, COG can be cooled to about 20 °C in primary cooler. Water and tar would condense out during COG cooling. After primary cooler, the tar mist in COG is further removed in the downstream electrostatic tar precipitators. The condensate from the cooling process and the precipitate from electrostatic tar precipitators are all led to the tar/liquor separator. The initial separation of tar and liquor is performed by gravity in the flushing liquor decanter. The high purity tar could be obtained after using centrifugal equipment to remove water and finer solids. This high purity tar could be sold for further refining offsite.

(2) H₂S/ NH₃ scrubbing / De-acidifier/ Sulfur recovery
After the COG is cooled down and tar is removed, the gas is sent to H₂S/ NH₃ scrubber. Crude COG contains hydrogen sulfide (H₂S) and various organosulfur compounds (carbon disulfide (CS₂), carbon oxysulfide (COS), etc.). The wet desulphurization techniques are highly efficient at removing H₂S and sulfur compounds. The COG is first fed into H₂S/ NH₃ scrubber at lower part. The water at the upper part of scrubber would flow downward to absorb the H₂S in COG. The scrubbing solution would be gathered at the sump and pumped to enriched solution tank in the top of de-acidifier (H₂S/NH₃ Stripper). The H₂S in enriched solution would be stripped out by steam in de-acidifier. The stripped H₂S would be sent to Claus reactor and recovered to element sulfur. The reaction of sulfur recovery is as below.

\[ 2 \text{H}_2\text{S} + 3 \text{O}_2 \rightarrow 2 \text{SO}_2 + 2 \text{H}_2\text{O} \]
\[ 4 \text{H}_2\text{S} + 2 \text{SO}_2 \rightarrow 3 \text{S}_2 + 4 \text{H}_2\text{O} \]

(3) Recovery of light oil from COG
The COG leaving H₂S/ NH₃ scrubber contains light oil which mainly consist of benzene (60~80%), toluene (6~17%) and xylene (1~7%). Those constituents could be removed from COG by using wash oil in a gas scrubbing vessel. After that, the light oil is stripped from the wash oil in a still and is condensed in a cooler to form crude light oil. This oil would be sold for further refining offsite. After the light oil is removed from the COG, COG would increases the calorific value and be suitable for use as a clean fuel.

(4) Water flow
The figure 3-1 also shows the main water flow in by-product plant. The water flow in by-product plant is mainly generated from coal moisture and the direct gas cooling liquor. In cooling process, the water would condense and flow to the tar/liquor separator. The separated water from tar/liquor separator (referred to as “coal water”) contains high
concentration of NH$_3$-N and is lead to the ammonia liquor storage tank for reuse as direct cooling water. The surplus water from the ammonia liquor storage tank is led to the de-acidifier. The stripped water from de-acidifier would be reused in H$_2$S/NH$_3$ scrubber. Water would be recirculated in de-acidifier and H$_2$S/ NH$_3$ scrubber for the removal of H$_2$S. Eventually, the excess water would be drained from the de-acidifier to the wastewater treatment plant. The wastewater from the de-acidifier in by-product plant is called as “coking wastewater” which contains high concentration of NH$_3$-N.

### 3.3 Removal of NH$_3$-N from Coking Wastewater

The coal water contains high concentration of ammonia because the ammonia in COG is washed to water during cooling process. To reduce the NH$_3$-N concentration in the coking wastewater, DSC has decided to install the caustic soda (NaOH) addition equipment and ammonia still unit in by-product plant. Since water in by-product plant tends to be acid, most NH$_3$-N in water would be present as ammonium and can’t be easily stripped out. Beside, about 20 - 50% of NH$_3$-N in water is fixed ammonia (some kinds of ammonium salt, such as ammonium chloride and sulfate) which also can’t be easily decomposed by heat in stripper. With the addition of NaOH, the water would be made alkaline so that the fixed ammonia in water could be decomposed into free ammonia (an example is given in the following equation) and ammonium would tend to become dissolved ammonia. In the ammonia still unit, the dissolved ammonia would be removed from water. The vapor from ammonia still unit would return back to de-acidifier for stripping enriched liquid. Eventually, the vapor containing ammonia gas discharged from de-acidifier would flow to Claus reactor and be reacted into nitrogen gas (N$_2$). After improvement, the water flow in by-product plant is shown in the figure 3-2. The excess water from the de-acidifier would not directly flow to the wastewater treatment plant, but be processed further in the ammonia still unit with addition of NaOH. After that, the NH$_3$-N concentration in coking wastewater can be reduced from to under 200 mg/L.

\[
\text{NH}_4\text{Cl} + \text{NaOH} \leftrightarrow \text{NH}_3 + \text{NaCl} + \text{H}_2\text{O}
\]
4. Improvement of Wastewater Treatment System

Besides removing NH$_3$-N pollutant in coking wastewater, DSC has improved its existing wastewater treatment system (depicted in the figure 4-1) to ensure the effluent to comply with the NH$_3$-N standard. Two main improvement measures are described below:
4.1 Enhanced Nitrification in Activated Sludge System

Nitrification is the biological oxidation of NH$_3$-N to nitrite and subsequently to nitrate (as to the reaction below).

\[
\text{NH}_4^+ \text{ (or NH}_3\text{)} + \text{O}_2 \rightarrow \text{NO}_2^- \text{ (nitrite) + 2H}^+ + \text{H}_2\text{O} \\
\text{NO}_2^- + \text{O}_2 \rightarrow \text{NO}_3^- \text{ (nitrate)}
\]

In a suitable environment, nitrifying bacteria (including ammonia-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB)) would be present in the aeration basin. The nitrification is likely to occur along with organic matter removal in the activated sludge system. Following BOD degradation in activated sludge, the NH$_3$-N is oxidized to nitrites and nitrate by nitrifying bacteria. The important parameters for nitrification reaction include temperature, pH, Alkaline, DO, organic loading rate, and SRT.

(1) Temperature

The suitable water temperatures for nitrifying bacteria is between 25 to 35 degrees Celsius (°C). Once the water temperature is higher than 45 °C, the activity of nitrifying bacteria is almost zero.

(2) pH and Alkaline

Nitrification is pH-sensitive. The suitable pH of nitrification is between 7 and 8. The rates of nitrification will decline significantly at pH values below 7. Also, nitrification would destroy alkalinity and result in a drop of pH. Theoretically, one gram of NH$_3$-N oxidized to nitrate would destroy 7.14 gram of alkalinity (as CaCO$_3$). The reaction is as follows. To maintain pH at optimum level, DSC has added lime in the aeration basin.

\[
\text{NH}_4^+ +1.83\text{O}_2 +1.98\text{HCO}_3^- \rightarrow 0.021\text{C}_3\text{H}_7\text{O}_2\text{N} +0.98\text{NO}_3^- +1.041\text{H}_2\text{O} +1.88\text{H}_2\text{CO}_3^- \\
\text{NH}_4^+ + 1.9\text{O}_2 + 2\text{HCO}_3^- \rightarrow 1.9\text{CO}_2 + 2.9\text{H}_2\text{O} + 0.1\text{CH}_2
\]

(3) DO

Both BOD degradation and nitrification in aeration basin would consume the dissolved oxygen (DO) in water. Theoretically, 4.57 gram of oxygen are needed to completely oxidize 1 gram of NH$_3$-N into nitrate. Under a low DO condition, the growth of nitrifying bacteria can be inhibited and incomplete nitrification would occur. Therefore, DSC has controlled the concentration of dissolved oxygen between 2 to 2.5 mg/L.

(4) Organic loading rate (F/M)

BOD degradation is performed by heterotrophic bacteria and nitrification is performed
by nitrifying bacteria (autotrophic bacteria). The heterotrophic bacteria are more competitive to utilize dissolved oxygen (DO) than autotrophic bacteria, and the growth rate of heterotrophic bacteria is substantially higher than that of autotrophic bacteria. The growth of autotrophic bacteria may be inhibited when the heterotrophic bacteria dominate the microbial community in the aeration basin. To provide an adequate growth potential for nitrifying bacteria relative to heterotrophic bacteria, DSC has reduced the organic loading rate (F/M) to the range between 0.8 and 1.2 (Kg BOD/ Kg MLSS-day).

(5) SRT
Since the growth rate of nitrifying bacteria (autotrophic bacteria) is lower than that of heterotrophic bacteria. DSC has increased the solids retention time (SRT, or sludge age) to maintain the healthy autotrophic populations. The short sludge age might lead to the excessive loss of viable nitrifying bacteria. The nitrification would be limited because of loss of autotrophic population.

The recommended parameters for nitrification reaction is given in the following table. With nitrification, above 70% of NH$_3$-N can be converted to nitrite or nitrate in the activated sludge system.

<table>
<thead>
<tr>
<th></th>
<th>Temp. (°C)</th>
<th>pH</th>
<th>DO (mg/L)</th>
<th>F/M (Kg BOD/ Kg MLSS-day)</th>
<th>SRT (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Improvement</td>
<td>15~38</td>
<td>6~9</td>
<td>0.5~1.5</td>
<td>1.5 ~ 2.0</td>
<td>20</td>
</tr>
<tr>
<td>After Improvement</td>
<td>25~35</td>
<td>7~8</td>
<td>2.0~2.5</td>
<td>0.8 ~ 1.2</td>
<td>28</td>
</tr>
</tbody>
</table>

4.2 Response to Abnormal Wastewater
Under the normal condition, the NH$_3$-N concentration would be largely reduced in by-product plant and activated sludge system. The NH$_3$-N concentration in the effluent from DSC could comply with legal standard.

To avoid the abnormal condition leading to the violation of effluent limitations, DSC had further ameliorated the wastewater treatment system by online analyzers, buffer basin, and stripping facility. The abnormal conditions include the lower NH$_3$-N removal rate in by-product plant or activated sludge system. DSC had built a 3000 cubic meter of buffer basin as the emergency storage. Once the online analyzers show the NH$_3$-N in water is in an unacceptable high concentration (the acceptable NH$_3$-N concentration in the system is shown in the table 4-
2), the water would be pumped to buffer basin for further stripping treatment. Because the stripping treatment isn’t used for high concentration of ammonia wastewater, air pollution wouldn’t be the concern.

<table>
<thead>
<tr>
<th>The position to measure NH₃-N</th>
<th>Coking Wastewater</th>
<th>Equalization in Biological System</th>
<th>Before Ozone Oxidation</th>
<th>Equalization in Industrial System</th>
<th>Before Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptable NH₃-N concentration (mg/L)</td>
<td>&lt;200</td>
<td>&lt;100</td>
<td>&lt;40</td>
<td>&lt;20</td>
<td>&lt;15</td>
</tr>
</tbody>
</table>

The improved wastewater treatment system is depicted in figure 4-2. The online analyzers, buffer basin and stripping facilities can work together as a backup system to effectively avoid the illegal wastewater discharge. Since all improvement measures were completed in October 2017, the NH₃-N concentration in DSC effluent is steadily lower than 15 mg/L, the average daily NH₃-N concentration in the effluent is only about 9 mg/L.
5. Conclusion
Considering ammonia can cause a deterioration in water quality, Taiwan EPA has announced a strict NH$_3$-N standard for many industries since 2011. Approximately, one ton of coke produced would generate 2~4 cubic meter of ammonia liquor. Dragon Steel Corporation (DSC) is an integrated steel plant with an annual production capacity up to two million tons of coke. The coking wastewater from DSC contains high NH$_3$-N concentration, which leads to the NH$_3$-N concentration in the effluent higher than the legal standard (20 mg/L). To reduce the NH$_3$-N pollution in wastewater, DSC has estimated several solutions for ammonia wastewater treatment.

After comparing possible technology and economic cost, DSC has completed the NH$_3$-N pollutant reduction plan to reduce the effluent NH$_3$-N concentration to less than the limitation, 20mg/L. The plan includes the removal of NH$_3$-N pollutant in coking wastewater, enhanced nitrification in activated sludge system and installation of buffer basin and stripping equipment as the backup system. To reduce the NH$_3$-N concentration in the coking wastewater, DSC had decided to install the caustic soda (NaOH) addition equipment and ammonia still unit in by-product plant. After improvement, the coking wastewater containing high NH$_3$-N concentration would not directly flow to the wastewater treatment plant, but be processed further in the ammonia still unit with addition of NaOH. In consequence, the NH$_3$-N concentration in coking wastewater can be reduced to less than 200 mg/L. In a suitable condition, the nitrification is likely to occur along with organic matter removal in the activated sludge system. The important parameters for nitrification reaction include temperature, pH, alkaline, DO, organic loading rate, and SRT. With nitrification, above 70% of NH$_3$-N can be converted to nitrite or nitrate in the activated sludge system. Eventually, to avoid the abnormal condition leading to the violation of effluent limitation, DSC had further built a 3000 cubic meter of buffer basin as the emergency storage. Once the online analyzers show the NH$_3$-N in water is in an unacceptable high concentration, the water would be pumped to buffer basin for further stripping treatment.

Since all improvement measures were completed in October 2017, the NH$_3$-N concentration in DSC effluent is steadily lower than 15 mg/L, the average daily NH$_3$-N concentration in the effluent is only about 9 mg/L.

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