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(WRS)

Operation Manual
Chrome Recovery Facility
Tanneries of Dokkarat
Fez, Morocco

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Environmental ***A***lternatives ***U***nlimited (**E.A.U.)**
B.P. 8967, Agdal - Rabat
Tel : (037) 77 37 88 / 77 37 98
Fax : (037) 77 37 92
E-Mail : proprem@iam.net.ma

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I. Introduction

The purpose of this Operation Manual is to provide supervisory and operating personnel with a thorough understanding of the technical aspects of chrome recovery. Detailed and specific instructions related to the operation and maintenance of each specific piece of equipment are found in a supplemental volume.

II . Overview of the Leather Tanning Processes

The tanning and finishing of leather consists of three basic steps:

- Beamhouse – unhairing
- Tanyard – tanning
- Finishing – retan, color, dying and finishing

Each process is unique and involves different physical and chemical processes.

In many tanneries the three processes are performed in separate vessels and in different areas of the tannery. One of the reasons for this is the totally different chemistry of the three processes. Safety, also is of concern, since commingling of the beamhouse and tanyard solutions may cause evolution of hydrogen sulfide gas.

A. Beamhouse

Hides may be received in the beamhouse in either "green" or salt-cured basis. Green is a terminology used to refer to a hide that has been recently removed from the animal. Preserved hides (salt-cured) have been subjected to a dehydration process using salt, and generally have been subjected to fleshing prior to salt-curing. Hides may then be sorted and fleshed. The fleshing process primarily is used on green hides to remove residual flesh from the inner surface of the hide. Salt-cured hides also may be subjected to a final fleshing process.

Hides are next loaded into a mixer for hair removal. Several different mixer designs may be used, but the basic operation is to keep the chemical solution and hide in an agitated condition during the process. The chemistry of unhairing is alkaline. Either sodium hydroxide (caustic soda) or calcium hydroxide (lime) is used to elevate the solution pH, and sodium sulfide is the depilatory (unhairing) agent. Depending upon the strength of the various chemicals in solution, the hair may be loosened, or totally dissolved. The extreme alkaline pH also swells the hide, allowing it to better accept the chrome in the subsequent tanning process.

Following unhairing, the hides may be sent directly to the tanyard, or go through an intermediate step of splitting. Splitting is a term used to describe a process in which the

grain side is split from the flesh side. This term is not to be confused with siding, which is an operation where the hide is cut down the backbone into two halves.

The “splits”, or flesh side, may not be sent to the tanyard, but rather sold as a lime split for purposes of collagen manufacture or artificial dog bones.

(See also Figure One)

B. Tanyard

In the tanyard, hides are subjected to an acid chrome (III) sulfate bath. The mechanics of the process are similar to the beamhouse, in that the process is carried out in an agitated vessel. These vessels often are constructed of wood and are called tan drums. Prior to introduction of chrome, a preliminary chemical process is carried out known as delime, or bate. The active chemical in the delime is ammonium hydroxide.

Following the alkaline processes, the hide must be prepared for tanning. Since the hide is alkaline, addition of the chrome sulfate, at this point in the sequence, would cause the chrome to precipitate on the surface of the hide, without penetration. First the hide is subjected to a pickle step, using a brine solution, followed by acidification. Once the hide has been acidified, it is now ready for application of chrome.

Chrome sulfate tanning chemicals are prepared by the reduction of sodium dichromate in a sulfuric acid solution with either glucose or sulfur dioxide (SO_2), according to the following simplified reaction:

$$\underset{\text{(glucose)}}{C_{12}H_{22}O_{11}} + \underset{\substack{\text{(sodium dichromate}\\ \text{Cr = +6)}}}{8Na_2Cr_2O_7} + \underset{\text{(sulfuric acid)}}{24H_2SO_4} \xrightarrow{\text{exothermic}} \underset{\substack{\text{(basic chrome}\\ \text{sulfate Cr =+3)}}}{16\ CrOHSO_4} + \underset{\substack{\text{(sodium}\\ \text{sulfate)}}}{8Na_2SO_4} + \underset{\text{(water)}}{27H_2O} + \underset{\substack{\text{(carbon}\\ \text{dioxide)}}}{12CO_2}$$

The basicity of the resulting chrome solution may be adjusted upwards by the addition of alkali, usually sodium hydroxide (NaOH), or downwards by the addition of sulfuric acid (H_2SO_4). Basicity is a terminology used in the tanning industry to define the form which chrome is present in the tanning solution:

$$Cr_2(SO_4)_3 = 0\%\ \text{basic} \qquad Cr(OH)_3 = 100\%\ \text{basic}$$

Virgin chrome (III) tanning preparations may be purchased in either liquid or solid (granular) form. Typical liquid commercial chrome tanning solutions are about 15% Cr_2O_3, with basicities values ranging from 25% to 50%, and the solutions can be spray dried to give powdered chromes of 23% to 26% Cr_2O_3. Self-basifying chromes may only be 19% to 20% Cr_2O_3, because of the presence of the basifying agent, such as, dolomite.

In the tanning sequence, the pH of the acid pickle may be in the range of 2.0 to 2.5 SU. If chrome is applied during the pickle, the chrome does not "fix" well into the leather because of the low pH, but rather moves in-and-out of the skin. At the end of the pickle, the chrome sulfate solution is applied, which raises the pH of the solution to about 3.0 SU. In a typical sequence, the tanning period may be several hours in length. During this period, mechanical energy of the rotating mill is transformed to heat, which raises the temperature of the hides and the chrome tanning solution approximately 20º C. The increased temperature speeds the chemical processes which allows the chrome solution to penetrate the hide and chemically combine with the leather (carboxyl groups). Some tan mills may be internally equipped with wooden pegs, which allow for more efficient transfer of mechanical energy to heat. If it is difficult to raise the temperature within the mill during the chrome tan, such as in small capacity mills, the length of run time must be extended, or hot water may need be added.

At the end of the tanning sequence, the pH of the solution within the mill is raised by the addition of alkali. This step is referred to as basification. Typical alkalis utilized are sodium bicarbonate ($NaHCO_3$) and magnesium oxide (MgO). In some formulae, the alkali (basifying agent) may be added in multiple steps, in order to minimize spotting or staining of the leather surface. The spotting and staining results from the formation of insoluble chrome hydroxide. At the completion of the basification step, the chrome is "fixed" as the pH of the tanning solution is elevated to 3.6 to 4.0 SU. The penetration of chrome into the leather is checked using the conventional "boil test". A typical range of chrome uptake into the leather may be 70% to 90%, which leaves a significant level of chrome in the exhaust solution. The uptake of chrome into the hide varies from one tannery to the next, depending upon the mechanics of the process employed, and the type of virgin chrome tanning preparation.

After the hides are removed from the drum, a process is employed known as wringing to remove surface moisture. The product of the process to this point is known as "wet blue". The name comes from the blue-green color imparted to the hide from the chrome (III).

C. Finishing

Wet blue next goes to a finishing operation, the end product being finished leather for use in the production of leather goods. The finishing operation varies from being relatively simple to a complex multi-step process depending upon the final use of the leather.

Generally, finishing may start with a retan step, where chrome is once again applied, only a far less vigorous application compared to tanning. Next the leather may subjected to chemical treatments to make it softer, waterproof, and so forth. The color of the leather is obtained by coloring (surface treatment) or dying (impregnation).

III. Generation of Wastewaters from Tannery Operations

A. Beamhouse

Beamhouse wastewaters are best characterized by the following general parameters:

- pH (alkalinity) – very high
- Biochemical Oxygen Demand (BOD) – very high
- Total Suspended Solids – very high
- Total Solids (organic and inorganic) – very high
- Sulfide Content – very high (warning - may liberate large quantities of hydrogen sulfide gas if pH is lowered!)

B. Tanyard

Tanyard wastewaters are best characterized by the following general parameters:

- pH (acidity) – very low
- BOD – low (relative to beamhouse)
- TSS – low (relative to beamhouse – some larger solids in the form of fleshings may be present due to inefficiencies in the initial fleshing process and also finely divided leather fiber from attrition with the tan drums)
- Total Solids – moderate (inorganic salts related to delime, pickle and chrome steps)
- Chrome (III) – high
- Ammonia – high (if ammonium sulfate is used in delime step)

IV. Sequence of Chrome Recovery Unit Operations

The recovery of chrome (III) from tanyard wastewater is a several step process. Each step in the sequence has a specific function and is necessary to the successful removal and recovery of chrome (III) from the tanyard effluents.

Again, depending upon the specific tannery operation, several distinct effluent streams may originate within the tanyard. Only those streams contaminated with chrome (III) are of concern in chrome recovery operations, and only those streams should be segregated and directed to the chrome recovery facility.

The two major sources of chrome (III) laden wastewaters in the tanyard are the exhaust from the tan drums and the wringer waters from the wringing of hides. Other fugitive sources may include drippings from the transport of hides from the drums to the wringer, losses where wet blue hides are stored, and miscellaneous spillage and leakage of chrome (III) bearing solutions and tanning preparations.

It is not necessary to capture the effluent from the delime or pickle steps in the sequence because these effluents would precede the addition of chrome (III) to the sequence. These effluents would have a deleterious effect on chrome recovery operations. Effluent from beamhouse operations must be segregated from chrome recovery, since commingling of the beamhouse effluent and tanyard effluent would have an very deleterious effect on chrome recovery and pose an imminent risk to human safety due to the potential formation of hydrogen sulfide gas.

Figure Two provides a general schematic of the chrome recovery sequence. Each unit operation is designated by name, and described as follows:

A. Screening (S-1)

1. Function

The function of the side-hill hydrasieve screen is to remove larger solid matter from the tanyard effluent. All wastewater entering the chrome recovery facility is first pumped over the side-hill screen. Larger solid matter present in wastewater is trapped on the surface of the screen, and falls downward into a hopper for subsequent disposal.

The type of solid matter trapped by the screen may include blue fleshings, scraps and trim, cross-contaminates and incidental solid matter discarded to the floor of the tannery and washed into the sewer with the tannery effluent, i.e., rags, cigarette butts, and miscellaneous debris.

2. Routine Operation

The hydrasieve screen has no moving parts and the only adjustment that can be made in its operation is controlling the flow rate to the screen. This is accomplished by the adjusting the valves on the discharge side of the pumps (SCP-1 & SCP-2) supplying the screen. The flow to the screen should result in a uniform flow over the weir at the top of the screen, yet not so great as to cause water to flow past the screen surface.

The amount of grease and fats in the wastewater will determine the frequency at which the screen surface must be cleaned. Grease and fats will “blind” the openings in the screen surface and cause the wastewater to simply flow over the screen, without passing through the openings. The screen surface can be periodically cleaned with a soft bristle brush and a mild detergent solution

B. Blue Water Receivers (T-1, T-2, T-3 & T-4)

1. Function

Following screening, the chrome effluent is directed towards one of four blue water storage vessels (T-1, T-2, T-3 & T-4). The function of the blue water storage vessels is to allow for quiescent conditions, which cause the grease and finely divided particulate matter to separate from the aqueous solution. This step in the sequence is of utmost importance, since it greatly effects subsequent unit operations. The "cleaner" the blue water obtained from this step, the easier the downstream treatment and the higher the quality of the recovered chrome.

For example, grease greatly impacts the operation of the filter press. It can rapidly "blind" the filter cloth and cause a lengthy filter press sequence time, or incomplete press cycle. In addition, the leather tanner is only interested in receiving back chrome (III) in the purest form possible for reuse in tannery operations.

Grease floats to the surface of the blue water storage tanks, while some of the finely divided leather fiber and other heavier debris will settle to the bottom. Each blue water storage tank is equipped with a grease collection trough for collection of the grease. Skimming of the grease is done manually with a grease skimmer.

2. Routine Operation

Routine operation of the blue water storage tanks would be to allow one tank to completely fill prior to filling the next. During the fill operation, sufficient turbulence is caused to disrupt proper separation.

Since the subsequent unit operations of precipitation and filter press dewatering can be accomplished relatively quickly, the total volume of all four storage tanks should be utilized to every extent possible.

Grease and skimmings can be removed by skimming the surface towards the grease collection trough. Since this will cause a slight lowering of the liquid surface, skimming should be done only once, and just prior to pumping the tank contents to the precipitation tanks.

Grease and skimmings are designed to flow to the Grease Washing Tank (T-10) by gravity. Should any plugging of this line occur, hot water and slight air pressure should clear the line.

The upper of the two valves on the blue water receivers should first be opened when transferring the clarified blue water from the receiver to either of the Precipitation Reactors (T-5 & T-6). Transfer pumps (BTP-1 & BTP-2) are used for this purpose. The clarity of the bluewater should be observed as it enters the Precipitation Reactors at the beginning of the transfer. If the bluewater still contains significant amount of grease or

solid matter, the transfer operation should be suspended, and the contents of the receiver examined to determine the cause of inadequate separation.

Once the contents of the receiver have been lowered to the level of the upper valve, the lower valve may be opened and the transfer continued. Note, the bottom valve, located on the conical section, is to be used for transferring sediment to the Sediment Washing Tank (T-11). Again, an observation should be made at the Precipitation Reactor to assure clarity.

After the contents of a Blue Water Receiver have been transferred to a Precipitation Reactor, the bottom valve on the conical section may be opened, and any accumulated sediment pumped, using the sediment pumps (SP-1 & SP-2), to the Sediment Washing Tank. The valves on the discharge side of pumps SP-1 & SP-2 should be adjusted to keep the flow at slow to moderate levels. This will prevent clear bluewater from being pulled through the sediment layer in the bottom of the conical section, a term known as "rat holing". At the onset of transfer of the sediment to the Sediment Washing Tank, and during the course of the transfer, the quality of the sediment should be visually monitored at the Sediment Washing Tank. Once clear bluewater is observed, this is an indication that all the sediment has been transferred, and the transfer should be terminated.

In summary, the quality of recovered chrome is highly dependent upon the quality of the bluewater processed downstream from the Blue Water Receivers. The more efficient the removal of extraneous matter at this point in the process, the easier and more efficient the downstream unit operations, as well as, the higher the quality of the recovered chrome.

C. Grease and Sediment Washing (T-10 and T-11)

1. Function

The purpose of washing the grease and sediment captured in the Blue Water Receivers is to remove any free chrome from these residuals prior to disposal. This step is necessary to minimize the total chrome in the effluent from the chrome recovery operation, and for the economics of chrome recovery. Since the chrome sulfate tanning chemical is readily soluble in dilute acid, this chemical is utilized for washing.

2. Routine Operation

Once a sufficient amount of grease and sediment have been accumulated in tanks T-10 and T-11, the washing operation can be conducted. Dilute sulfuric acid, made up in tank T-9 is transferred using pump DAP-1 to either the grease (T-10) or sediment (T-11) washing tanks. The concentration of dilute sulfuric acid needed for adequate removal of free chrome can be adjusted for maximum efficiency. Generally, a 5% (by volume), or less, solution is sufficient.

The total volume of grease or sediment collected should not exceed 1/3 the volume of either Tank T-10 or T-11. An equal volume of dilute acid can be added, such that the

total volume does not exceed 2/3rd of the tank volume. This allows for a 1/3rd volume freeboard, and sufficient free volume in the tank for agitation.

Once the dilute acid has been added, the mixer can be started, and the contents agitated. The mixers on both T-10 and T-11 are equipped with variable frequency drives (VFD), so the mixer is started at low speed, and the speed adjusted upwards to cause the proper level of agitation. Generally, about 1/2 to 1 hour of agitation is sufficient to remove most of the free chrome from either the grease or the sediment.

Following agitation, the mixer is shut off, and the contents allowed to separate. The grease will again float and the sediment will again settle. The quiescent period needs be sufficient, usually several hours, to allow for adequate separation.

Following separation, the separated bluewater is drained to the facility sewer, and the grease and sediment drained to the general sewer.

D. Dilute Acid Preparation (T-7)

1. Function

Dilute sulfuric acid is prepared for use in washing residual matter (grease, sediment and screenings) to remove free chrome.

2. Routine Operation

Dilute acid is prepared in the Dilute Acid Preparation Tank (T-7) by adding concentrated sulfuric acid to water.

The Dilute Acid Preparation Tank is filled about 3/4ths full with fresh water and the VFD controlled mixer started at slow speed. The mixer speed is increased to a level where good agitation is achieved in the tank. Concentrated sulfuric acid is added from the Sulfuric Acid Storage Tank (T-14) using pumps SAP-1 or SAP-2. The concentrated acid is slowly added to the agitated water. Significant heat will be evolved when adding concentrated sulfuric acid to water, so the operation must be conducted slowly and with utmost precaution and attention to safety. The final concentration of acid in solution should be approximately 1% to 5%, weight basis.

E. Precipitation of Chrome (T-5 and T-6)

1. Function

The function of the Precipitation Reactors (T-5 & T-6) is to precipitate the soluble chrome sulfate ($Cr_2(SO_4)_3$)from the acidic bluewater as insoluble chrome hydroxide ($Cr(OH)_3$). This is done by elevating the pH of the acid bluewater to a pH level where chrome is most insoluble.

Studies using sodium hydroxide as the alkali to elevate solution pH have shown chrome hydroxide to be least soluble in a pH range of approximately 8.6 to 9.7 su. A good target pH is 9.2 su, as a pH of stability. It is important to note that the solubility of chrome increases once the upper limit pH of 9.7 is exceeded.

The precipitation reaction is controlled not only by pH, but also by temperature. Cold bluewater (<20º C) will take much longer to react in precipitation than warm bluewater (>30º C).

2. Routine Operation

Once a Precipitation Reactor has been filled with clarified bluewater, the precipitation reaction can be conducted. The pH of the starting solution should be noted.

Each of the Precipitation Reactors are equipped with a mixer controlled by a VFD. The mixer is starter at low speed, and the speed is increased until a high level of agitation has been achieved.

Aqueous caustic soda is added using pump CP-1 from the Caustic Preparation Tank (T-8). The pump CP-1 is equipped with an automatic batching system to allow for precise additions of caustic solution to the reactor. The amount of caustic to be added is highly dependent upon the pH and the concentration of chrome in the bluewater. Therefore, it is suggested the automatic batching system be used only for the initial adjustment of pH, and manual operation of pump CP-1 be used for final adjustment of pH.

Initial pH adjustment should be to a level of 9.2 to 9.5 su and the contents of the reactor left agitating for a period of 30 minutes to two hours, depending upon the temperature of the contents. As the reaction proceeds, the pH of the solution will decrease. In is not uncommon for the initial pH to fall upwards of one su unit. After the initial reaction has is completed, more aqueous caustic may have to be added to stabilize the pH at 9.2 su.

Once the pH has stabilized, the next step is to flocculate the chrome precipitate with dilute polymer. Aqueous polymer solution is added using pump PP-1 from the Polymer Preparation Tank (T-7). Addition of polymer is very similar to the addition of caustic. Pump PP-1also is equipped with an automatic batching system to allow for precise additions of polymer solution to the reactor. The amount of polymer to be added is highly dependent upon the level of precipitated chrome in the reactor. Therefore, it is suggested the automatic batching system be used only for the initial flocculation, and manual operation of pump PP-1 be used for “fine tuning” the flocculation.

Once the flocculation is complete, the mixer is stopped and the flocculated chrome precipitate is allowed to settle in the reactor. Settling time generally ranges from one to four hours.

Following settling, the clear decant can be emptied from the reactor. Analytical testing of the decant for residual chrome is done through the use of an Atomic Adsorption

Spectrophotometer. However, the eye is very keen at determining residual levels of soluble chrome in dilute aqueous solutions. A "crystal clear" decant, when viewed through a clear glass vessel, generally will not contain chrome (III) in levels exceeding a few parts per million. If any blue tint remains, the precipitation reaction was not carried to completion, flocculation was inadequate, or something interferred with the reaction.

Clear decant is emptied from the Precipitation Reactor by sequentially opening the valves on the side of the reactor starting with the top valve first. During the draining of decant, the visual quality should be observed at the floor sewer. If any precipitate, or blue color appears in the decant, the decanting should be terminated, at that point.

Optional procedures are available at this point in the sequence. For example:

- If a sufficient quantity chrome precipitate is available in the reactor(s) to fill the Filter Press (F-1), as configured, the precipitate may be sent to the Filter Press.

- If an insufficient quantity of precipitate is available, the reactor can once again be filled with clarified bluewater on top of the precipitate already present in the reactor, and the precipitation procedure repeated.

- Once a sufficient quantity of precipitate is available, the reactor can be filled (or partially filled) with fresh water, agitated for a few seconds using the mixer on slow speed, and the precipitate allowed to resettle. Once the precipitate has resettled, the clear decant can once again be emptied. This optional procedure is known a "washing" the precipitate, and allows for removal of extraneous soluble salts, which provides for a more pure form of recovered chrome.

F. Caustic and Polymer Preparation (T-7 & T-8)

1. Function

As noted in the previous section, aqueous solutions of caustic and polymer are necessary to precipitate and flocculate the chrome contained in the clarified bluewater.

2. Routine Operation

Polymer is prepared in the Polymer Preparation Tank (T-7) by adding granular polymer to water. The specific polymer most widely used is manufactured by Stockhausen and designated Praestol 2540 TR.

The Polymer Preparation Tank is filled about 3/4ths with fresh water and the VFD controlled mixer started at slow speed. The mixer speed is increased to a level where good agitation is achieved in the tank. The dry granular polymer is next added slowly to the agitated water. This procedure is critical so as not get any lumps, or "fish eyes", in the solution. The final concentration of polymer in solution should be approximately 0.035% weight basis.

Once the polymer solution has been prepared, the mixer should be left running on slow speed for several hours, and the polymer solution allowed to "age" at least 12 hours prior to use.

Caustic is prepared in the Caustic Preparation Tank (T-8) by adding dry sodium hydroxide to water.

The Caustic Preparation Tank is filled about 1/2 full with fresh water and the VFD controlled mixer started at slow speed. The mixer speed is increased to a level where good agitation is achieved in the tank. The dry sodium hydroxide is next added slowly to the agitated water. Significant heat will be evolved when adding dry sodium hydroxide to water, so the operation must be conducted slowly and with utmost precaution and attention to safety. The final concentration of caustic in solution should be approximately 40% - 50%, weight basis.

G. Filter Press (F-1)

1. Function

The function of the Filter Press (F-1) is to dewater the precipitated chrome hydroxide produced in the Precipitation Reactors (T-5 & T-6).

In order to reconstitute the chrome, at a suitable concentration for reuse in the tanneries, the moisture content must be reduced to the very lowest level attainable with the filter press. The press should be operated in such a manner as to achieve this objective.

2. Routine Operation

The specific filter press used on this project is equipped with various automation and accessories. It is not the intent of this Operation Manual to discuss each of the options, and the various configurations by which the filter press may be operated. Rather, it is the intent to describe the basics of routine operation.

The Filter Press is supplied with chrome precipitate from the Precipitation Reactors (T-5 & T-6) using the Filter Press Pumps (FPP-1 & FPP-2). Once the press is closed a secured, the valve and the bottom of the conical section of the Precipitation Reactor is opened and the filter press pump(s) started. The filtrate diversion valve, should be opened, allowing the filtrate to initially drain to the internal building sewer. This is done so if chrome is present in the filtrate it remains contained within the chrome recovery facility.

The quality of the filtrate can be checked by analytically, or by the visual test described in Section E-2 of this Manual. If the filtrate is "crystal clear" in appearance, the diversion valve can be closed, and the filtrate sent to the discharge sewer.

At the start of the sequence, the Filter Press Pumps will be pumping very rapidly to fill the press with wet precipitate. As the dewatering process continues, the speed of the pumps will slow, and finally come to a near stop condition. It is at this point that the flow of filtrate will nearly stop (come to a trickle), and the pumps can be shut off.

At the completion of a filter press cycle, the press may be opened, one plate at a time, and the filter press cakes allowed to drop into the Acidulation Tank (T-12). Once all of the cakes have been removed, the Filter Press may be closed and readied for the next batch of precipitate.

H. Acidulation (T-12)

1. Function

The principle function of acidulation is to chemically convert the dewatered chrome hydroxide ($Cr(OH)_3$) to acid chrome sulfate ($Cr_2(SO_4)_3$). It is the acid chrome sulfate solution that the tanners can use in their tanneries to supplement the usage of virgin chrome.

2. Routine Operation

Once a complete press load of filter cakes have been unloaded into the Acidulation Tank (T-12) the in-line Exhaust Fan must be started. Fumes are evolved once the addition of concentrated sulfuric acid is started, and adequate ventilation is mandatory.

Concentrated sulfuric acid is pumped from the Sulfuric Acid Tank (T-14) to the Acidulation Tank using pumps SAP-1 and SAP-2. Initially, a quantity of 200 liters of sulfuric is pumped to the Acidulation Tank. The automatic batching system controlling pumps SAP-1 and SAP-2 may be used for this purpose. The mixer is started at slow speed using the VFD. The initial addition of sulfuric acid should be sufficient to create a slurry, operating the mixer at slow speed, within a period of one-half hour. If a complete slurry is not created, evidenced by large pieces of intact filter cake remaining, additional acid may be added.

Once a uniform slurry has been obtained, the mixer speed can be increased. Additional acid may be added in 10 liter increments until the slurry is transformed into a clear dark green solution. Samples of the acidulate should be taken during this process in order to monitor the progress of the operation.

I. Recovered Chrome Storage (T-13)

1. Function

Storage of recovered chrome provides for a reservoir from which the tanners can obtain the product for use in their tanneries.

2. Method of Operation

Recovered chrome is transferred from the Acidulation Tank (T-12) to the Recovered Chrome Storage Tank (T-13) using pump AP-1.

V. Safety

Of prime importance to the successful operation of the chrome recovery facility is safety of all personnel associated with the operation.

Areas of concern include the potential formation of hydrogen sulfide gas and safe handling procedures of chemicals.

The facility is equipped with a hydrogen sulfide gas detection system. The operation and testing of this system should be reviewed and understood fully by all personnel involved with the operation of the facility. Hydrogen sulfide can be formed by the commingling of beamhouse and tanyard wastewaters, and therefore represents a safety concern.

Operation of the chrome recovery facility requires the use of strong acid and alkali solutions. All personnel involved in the operation of the facility should be thoroughly trained in all safety aspects of handling these chemicals. Protective clothing, eyewear, and breathing apparatuses and safety procedures should be employed at all times when handling these chemicals. The facility is equipped with safety showers and eyewash stations and all personnel should be thoroughly trained in the use of these devices.

<u>Safety must be number one in any and all operating procedures</u>!