A P_2O_5 Recovery Evaluation at the South Pierce Plant: Findings of the P_2O_5 Recovery Focus Group

By

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ABSTRACT

The IMC-Agrico Plant at South Pierce is a phosphate complex which produces roughly 600,000 tons per year of P_2O_5. The plant employs wet rock grinding and a Dorr-Oliver annular reactor. Approximately half of the plant P_2O_5 output is consumed internally in its GTSP plant, the other half of the P_2O_5 production is exported to other IMC-Agrico plants.

During the first 2 quarters of 1997, South Pierce detected a decline in P_2O_5 recovery. A focus group was formed in order to pinpoint the cause of the problem and to recommend methods for improving recoveries. A focus group is a team with a single task, a limited scope of study and a fixed timetable for project completion. This particular group included members from the Accounting, Distribution, Engineering, Laboratory and Production departments.

The group was directed to identify the factors causing the decline in reported recoveries. To accomplish this, the group investigated the mechanics of the recovery calculation to determine if the numbers generated were reliable. During the course of the evaluation a number of errors, inaccuracies, and improper procedures were identified and corrected. At the conclusion of the study, the reliability of the recovery calculation was improved and several key items were targeted for further investigation.

This paper describes the mechanics of how a focus group investigation operates. It describes how the errors in the recovery calculation procedure were detected, how the system was modified to develop a reliable recovery number, and where future evaluations will be directed.

HISTORY AND COMPOSITION

The P_2O_5 Recovery Study at South Pierce started in August of 1997. Its purpose was to evaluate a decline in the reported PhosAcid recoveries at South Pierce, and to propose methods for improving recoveries.

The study was done using the "Focus Group" technique. This technique uses a group that is selected for a single task. The group works on a self imposed deadline and a narrow scope of study. A trained "Facilitator" is used to direct the start-up of the study and to develop a consensus within the group on the scope and timetable of the study.

The P_2O_5 recovery group was selected to include representatives from the Accounting, Distribution, Engineering, Laboratory and Production departments. In its first meeting, the group defined the problem, listed the expected outcomes of the study and created a timetable for execution of the study. The outline they developed for the study is shown below:

MISSION STATEMENT

Identify factors causing the decline in reported recoveries.

DEFINING THE PROBLEM

- What are the components of the reported recovery?
- What are the causes of the fluctuations in recoveries?
- What are the sources of P_2O_5 losses?

EXPECTED OUTCOMES

- Clarify the variables used in the recovery calculations
- Develop a set of realistic recovery numbers
- Identify any recovery problems

TIMETABLE FOR THE STUDY

Gather data-4 months	Evaluate-2 months	Propose-1 month
identify inputs	track historical trends	develop priorities
determine sensitivity	analyze statistics	determine costs
review formulas	review plant operations	make recommendations

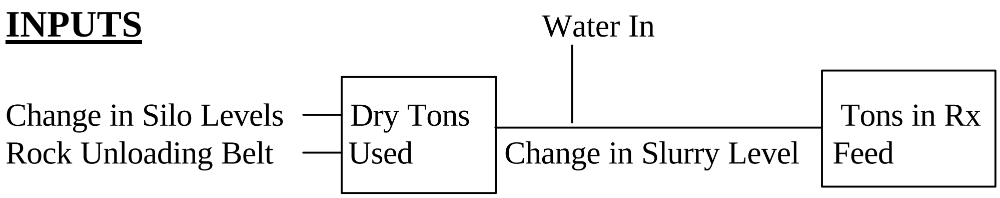
STEP I

HOW IS RECOVERY CALCULATED?

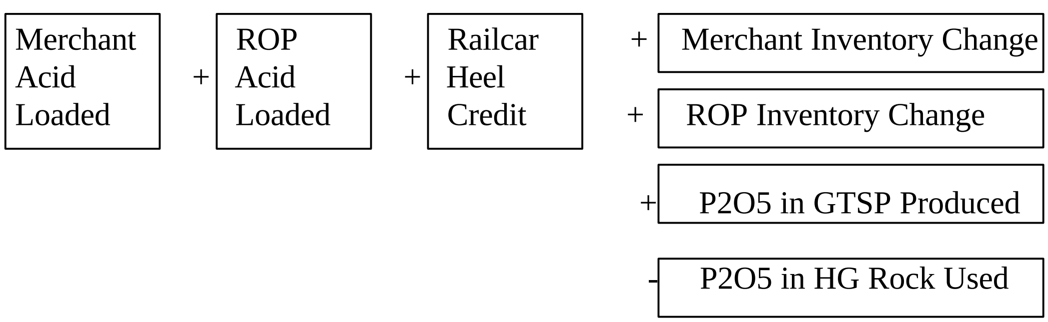
COMPONENTS OF THE RECOVERY CALCULATION

The general components of the South Pierce Recovery Calculation are shown in the block diagram below. The plant has 3 products, Centrifuged Acid (Merchant), Uncentrifuged Acid (ROP), and GTSP. The other item considered as output is P2O5 reclaimed from railcar heels, washed in the recovery facility.

INPUTS



OUTPUTS



OUTPUTS / INPUTS X 100=RECOVERY

*The conversions for dry tonnage P2O5 are not shown in the block diagram for clarity.

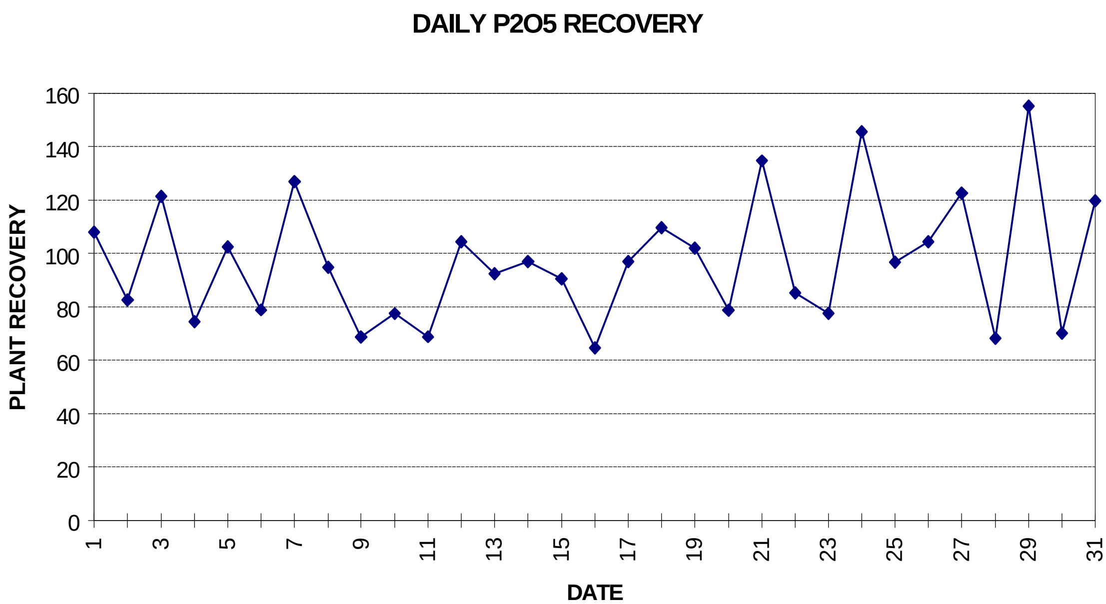
*The calculations for P2O5 recovery are done on a dry tons P2O5 basis.

ANALYSIS OF THE RECOVERY CALCULATION

In the beginning of the study, most of the group was surprised to find that recovery was being calculated simultaneously, in two separate departments. The daily recovery was being calculated by Production Accounting at the New Wales complex, and the month end recovery was being calculated by the Cost Accounting Department at the Bartow office. This added to the complexity of the evaluation, as the group now had 2 separate sets of calculations to consider.

The group decided to limit its study to the daily recovery calculation, as this was the logical tool for Production to use to track losses. It was assumed by the group that if a problem was located in the daily recovery calculations, it was probably duplicated in the monthly numbers. Any corrections made in the daily analysis would be passed on to the Accounting Department at Bartow to correct the monthly analytical sheet. Any reference to recoveries from this point on, refers to the daily recovery.

An initial concern of the group was the wild swings in recoveries, varying from 160% to 60% in a single day. This was an unrealistic reflection of recovery, which would have to be corrected before anyone would have any confidence in the numbers. Eliminating the variability of the daily recovery calculation became a primary goal of the focus group.



The first step in the evaluation was to find out how recovery was calculated. This would help determine if the recovery problems were actual losses or accounting errors. At this point; the logic of the calculation was examined, assumptions made in the formulas were checked, inputs were identified and checked for accuracy, and the sensitivity of the calculation to changes in inputs was evaluated.

CALCULATION LOGIC

The general logic of the recovery calculation was determined to be sound. However, some small errors were detected. An adjustment for incoming rock moisture was being made twice in the formula and this was corrected. It was also determined that the calculation was not giving credit to the ball mill for the recovery of P_2O_5 from the pond water consumed at that point. The calculation was modified to include that credit, and resulted in an increase in reported P_2O_5 recovery of approximately 200 tons per month.

ASSUMPTIONS IN THE FORMULA

Two errors were located in the base assumptions. The 90 pound per cubic foot density used for rock dust was too low. This was corrected to current measured density and this resulted in a slight increase in calculated inventory. The density used for the rock slurry was also too low. The original formula was based on 64 percent solids in the reactor feed, the correct density was based on 68 percent solids to the reactor. This error was the result of a gradual increase in the reactor feed solids target over a period of years. This correction also resulted in an increase in inventory.

ACCURACY OF INPUTS

About 20 key inputs to the recovery calculation were identified. The accuracy of most of these inputs was determined to be acceptable, but 5 were suspect. The questionable inputs were identified as: rock percent moisture going to the silos, measured wet rock level in the silos, rock feed to the reactor, percent P_2O_5 in the reactor feed, and percent P_2O_5 in the blend acid. These inputs were targeted for further evaluation; to determine if changes in sampling, changes in calibration procedures, or installation of new equipment would be necessary.

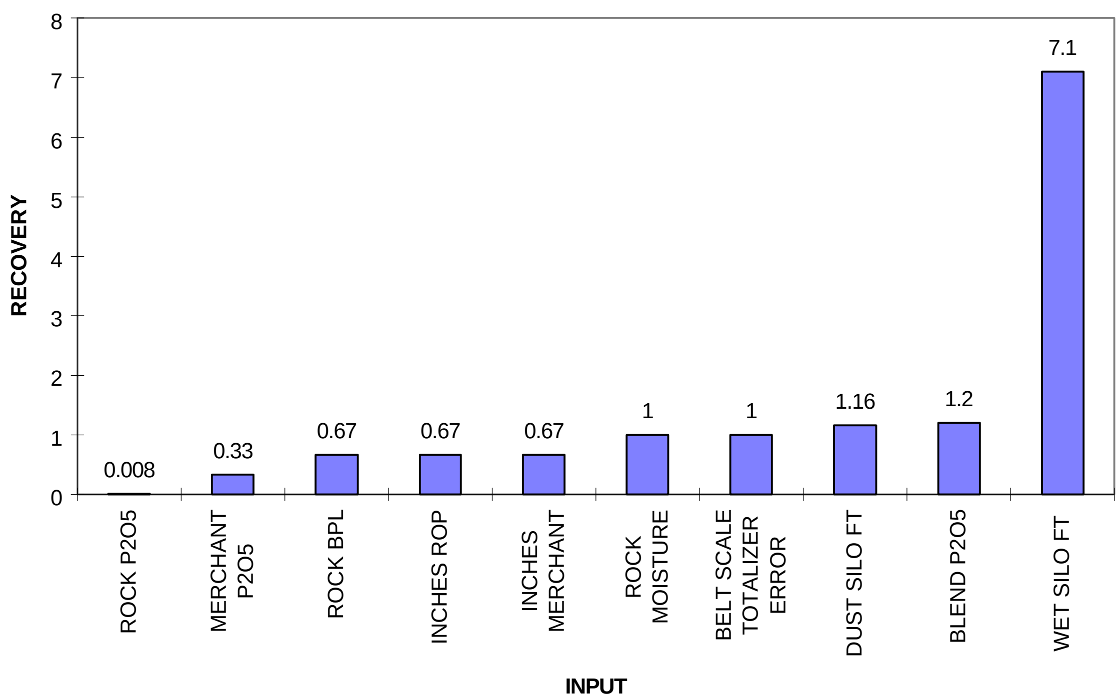
SENSITIVITY OF THE ANALYSIS

The sensitivity of the recovery calculation to variations in the input values was determined next. Sensitivity was defined as the amount of change in calculated recovery resulting from a unit change in an input. This tool was used to determine which input variables would cause the biggest change in recovery.

It was important that these "sensitive" inputs were determined as accurately as possible. An error here would mask any other change in recovery. This was the analytical tool that pinpointed the source of the huge recovery swings.

As you can see on the following sensitivity chart, changes in the wet rock silo level had the greatest effect on reported recovery. This graph demonstrates that if a 1 foot error was made in the silo strapping, it distorted the total plant recovery by 7 percent. Unfortunately, as we discovered later, this particular measurement had a host of errors.

CHANGE IN RECOVERY FOR UNIT CHANGE IN INPUT



The results of the sensitivity analysis focused the groups attention on all variables with a sensitivity of 1 or greater. The analysis also targeted the maximum effort into the reduction of error on the wet silo numbers.

STEP II

WHERE ARE THE SAMPLES COMING FROM?

EVALUATION OF PLANT OPERATIONS

Now that the group understood the mechanics of the recovery calculation, it was time to evaluate how the recovery data was being collected by the plant. Each variable which had a questionable degree of accuracy or was found to be "sensitive" in the recovery calculation was rigorously examined.

MOISTURE AND PERCENT P2O5 DETERMINATION

The moisture and P_2O_5 numbers are generated at the mines and marked on the invoice with the incoming cars. We conducted an inspection tour of the mines and found that the product was sampled by periodically shoveling a small portion of the shipping hopper discharge into an open bucket. This was an acceptable technique for a P_2O_5 determination, but a moisture analysis taken from this open sample would have been useless.

It was later found that the incoming moisture used in the recovery calculation was not based on an analysis, but was an estimate generated by Operations. The ball mill feed was sampled and analyzed for moisture content, instead of the incoming rock. This number was then adjusted by an assumed moisture loss in the silos and used as the incoming rock moisture.

This was determined to be an acceptable indicator, but not the best. An in-line sampler on the incoming rock belt was proposed as the optimum solution.

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ROCK INVENTORY

When the cars are unloaded at South Pierce, the rock is totalized as it is delivered to the silos. The problem here is one of ergonomics. As each string of cars is emptied, the operator logs the individual car numbers and the silo destination. He then walks 100 feet away to the mechanical totalizer on the inclined belt. He climbs onto a small platform and notes the weight of the string of cars unloaded, and then returns to log the totalized weight.

If the weight is incorrectly recorded, the consumption of rock will be reported as too high or too low, biasing the recovery. If the totalizer readings could be relocated to the logbook area, the amount of separate activities would be reduced, along with the chances for error. The mechanical totalizer has now been modified to provide a remote readout at the logbook area.

The calibration and PM frequency of the belt scale and mechanical totalizer was determined to be acceptable. However, in order to reduce the maintenance requirement on this scale, it was recommended that it be replaced with an electronic scale when economically feasible.

The wet rock is delivered to one of six rock silos. Rock usage is determined by the totalized rock feed to the silos and the change in silo levels. The level in the silos is determined by a strapping. It was found that the operators were not using the same strapping point with each silo. A standardized gauge point was fitted to each silo to eliminate this problem.

The strapping tape used by the operators was made of vinyl and had been used so often that some of the numbers had been wiped off completely and the last 18 inches of the tape was missing. A steel tape replaced the vinyl one, and this problem also went away.

The biggest problem we found was that the levels were reported in one foot increments. This was done to accommodate a computer look-up table. This meant that if any error was made, the inventory would be off by at least 50 tons. When this error is multiplied by 6 silos, the potential effect is enormous. The formula was changed to allow the input of inches and feet, and the error became 1/12th of the original amount.

ROCK SLURRY INVENTORY

The ground rock slurry is stored in 2 tanks. An error was located in the assumed rock density of the slurry and a new strapping chart was developed to calculate inventory in the tanks.

In the investigation, we discovered that like the wet rock silos, the slurry tanks are also measured in 1 foot intervals. This also generated a minimum 50 ton error for any bad reading. The rock slurry inventory calculation will need to be modified to allow readings in feet and inches to reduce this error to acceptable levels. Due to time constraints, the group was not able to get this modification implemented.

SLURRY FEED TO THE REACTORS

In the initial phase of the study, the value from the slurry totalizers was suspect. The slurry feed totals to the reactors are taken from mag-meters installed on the 2 reactor feed lines. It was determined that the meters were calibrated electronically on a monthly PM schedule. This was deemed to be adequate for signal accuracy, but it would not pick up any drift between the sensor and the pulse counters. A drift would cause over or under reporting of feed to the reactors and a bias in the recovery. The group recommended periodic tank draw-down testing on the meters to eliminate drift. Production has agreed with this and is scheduling testing.

SLURRY BPL TO THE REACTORS

The slurry BPL is currently determined from 2 hour grab samples, which are composited over the length of a shift. In order to evaluate if on-line sampling would improve the accuracy of the sample, a plant trial was initiated by the group. Comparing the BPL of the grab sample with the BPL of a sample compiled every half hour would show if any significant improvement could be realized with an automatic sampler. The results of the trial indicated that there was no significant difference between the grab sample and the rigid composite. As a result of this evaluation, an on-line sampler was determined to be unnecessary.

BLEND P2O5 TO THE GTSP PLANT

The blend P_2O_5 to the GTSP plant is also determined by grab samples. These samples are then composited over a shift. During the course of the study, we were able to run a comparison of the grab sample to a rigid composite. In this evaluation we again found that there was no improvement in accuracy with the composite. No change in procedure was recommended for this sample.

STEP III

WHERE DO WE GO FROM HERE?

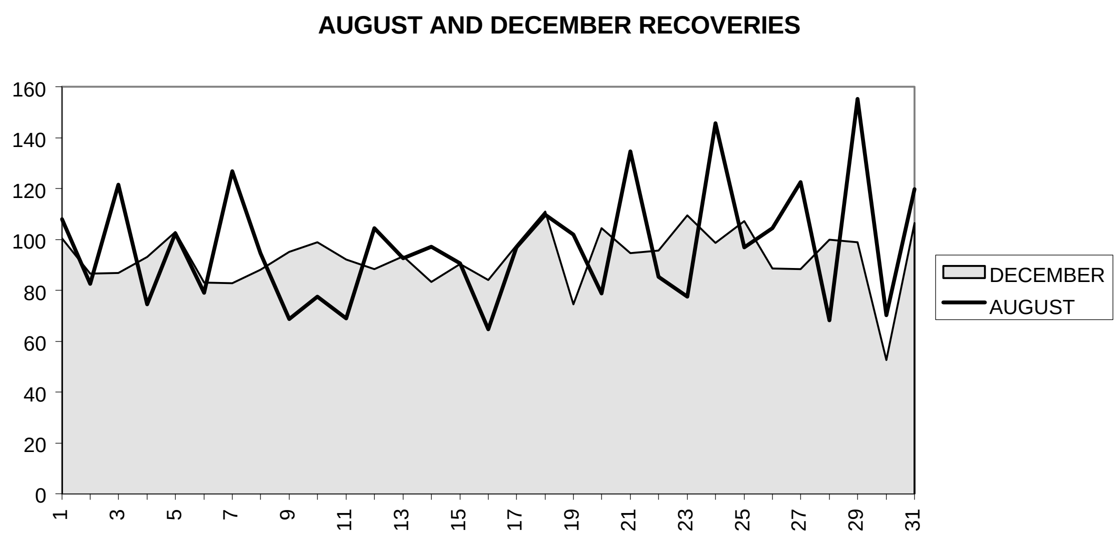
EVALUATION OF THE MODIFICATIONS MADE

At this point in the investigation, the group was satisfied that the recovery calculations were now correct. The plant sampling procedures and equipment had been checked, and modifications had been made where necessary. It was time to evaluate the effectiveness of the changes implemented by the group.

REDUCTION IN DAILY RECOVERY SWINGS

The biggest improvement that the group noted was a significant reduction in daily recovery swings. The standard deviation of the daily recoveries had been cut in half. This change was the result of reducing the sensitivity of the wet rock inventories. The change-over from feet to inches in silo strappings resulted in an order of magnitude reduction in sampling error.

The following graph plotting August recoveries, at the beginning of the study and December recoveries, near the end of the study, demonstrates the reduction in recovery swings.



INCREASED CONFIDENCE IN THE ACCURACY OF SAMPLES

The recovery study has improved the plant confidence levels in the accuracy of the samples.

In some areas, the accuracy of the existing sampling was confirmed. Plant personnel originally felt that on-line samplers would be required to guarantee sample reliability. The study demonstrated that the existing grab samples were adequate. The plant thought that meters were rarely calibrated. The group found that the meters used in recovery were being electronically calibrated every month.

In some areas, the accuracy of the sampling was improved. The confusion as to where to sample the rock silos has been eliminated with the installation of permanently mounted sample points for each silo. A reduction in sampling tasks, and the possibility of recording errors, has been accomplished with the relocation of the incoming rock totalizer readout. Draw down testing is being initiated and early tests of the sulfuric meters located a significant offset in its totalizer signal.

IMPROVEMENTS IN REPORTED RECOVERY

The reported P_2O_5 recovery has improved by roughly 200 tons per month due to the inclusion of consumed pond water at the ball mills.

The recovery study has re-familiarized the Production Accounting group with the mechanics of the recovery calculation. The group now better understands the impact of each section of the analysis. This understanding resulted in picking up a calculation error in January that, once corrected, shifted recovery almost 2 percent higher for the month.

Analysis of overall plant recovery is now possible because recovery is now a believable number. Shifts in recovery that were undetectable before are now identifiable. This has resulted in several new studies, relating recoveries to production rates and other variables.

The biggest improvement, though hard to quantify, was the cross-department ownership of the recovery program. Because the study required the active participation of Accounting, Distribution, Engineering and Production, each department bought-in to the final form of the program. Each department made sure that its input had been accommodated during the study, and now each would share responsibility for maintaining the program in the future.

PROPOSALS FOR FURTHER IMPROVEMENT

The Recovery Focus Group was, by design, a short term study. When the evaluation was completed in January 1998, the group was disbanded. This resulted in a number of items which could not be completed and would require further activity. These items would have to be developed by the Engineering department or by future study groups.

FURTHER INCREASE IN THE ACCURACY OF SAMPLE INPUTS

Due to the sensitivity of the recovery calculation to incoming rock moisture, an accurate sample is required. This is the one area that the group felt could be best served by a continuous sampler.

Draw-down testing of the sulfuric tanks and rock slurry tanks need to be set up as a routine PM procedure. Electronic calibration of the pulse signal is not adequate because of sensor drift. The study confirmed that drift was a problem and that it was occurring in key areas. Draw-down tests could not be scheduled realistically on a monthly routine, but testing on a quarterly basis should be possible.

REFINE RECOVERY CALCULATION

Towards the end of the study, it became apparent that the recovery of the sludge heels in acid railcars was not being handled properly. The recovery calculation assumed a heel P_2O_5 value based on past experience with cleaning merchant acid railcars. The typical acid railcar received at South Pierce contained ROP. The ROP heel contains a higher percentage of gypsum, and its P_2O_5 value is lower. In calculating all recovered heels as merchant, we were over-reporting P_2O_5 returning to inventory.

To determine the bias due to ROP heels, a study of the difference between merchant acid and ROP heels needs to be done. When this is completed, a modification in heel credits will be made.

CALCULATE RECOVERIES IN EACH UNIT OPERATION

The final recommendation of the group is to improve the value of the recovery calculation, as a tool for production. The existing calculation looks at overall plant recovery. This is OK as a tool to alert Production that a problem exists, but it really does not point Production to where the problem is occurring. Individual recovery calculations at each major unit operation need to be developed.

These calculations need to be done in the plant, independently from the Accounting Group. Accounting lacks the resources to process the additional information, and the plant personnel are the ones who will benefit from the individual area recovery information.

Daily recovery formulas need to be developed for Primary PhosAcid, Filtration, Evaporation and GTSP. Once these formulas are installed and a history is developed, any change in individual area losses will show up almost immediately.

IN CONCLUSION:

- **WE FOUND OUT WHAT WE WERE ACTUALLY DOING, NOT WHAT WE SAID WE WERE DOING.**
- **WE FIXED WHATEVER WAS BROKEN, AND LEFT WHAT WORKED ALONE.**
- **WE FIGURED OUT WHERE WE WANTED TO GO NEXT.**