

EIGHTH APPLICATION COURSE

COPY

TQC SEMINAR

PRESENTATION MATERIAL FOR APPLICATIONS STUDY GROUP

THEME: IMPROVEMENT OF CONTROL METHODS REGARDING THE
HYDRAZINE CONCENTRATION IN BOILER FEED WATER

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Reasons for Theme Selection

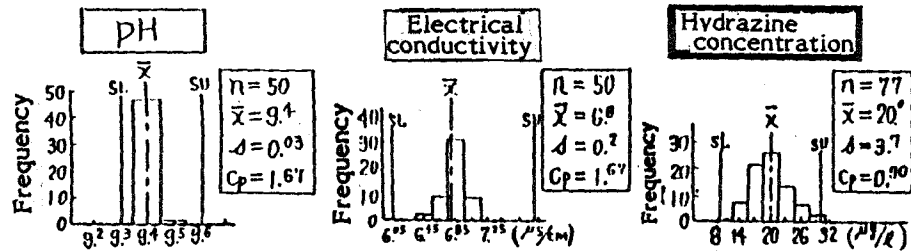
Background

Section Chief's Priority Action Item for Fiscal 1986

Enhanced reliability of water quality monitoring

Current Status of boiler feed water quality

Feed water quality status
(Results of analyses for the first half of the year 1986)



Problem

Though boiler feed water processing is automatically controlled, working procedures, such as adjusting the quantity of hydrazine are necessary to compensate for variations in the hydrazine concentration which have come close to control limits.

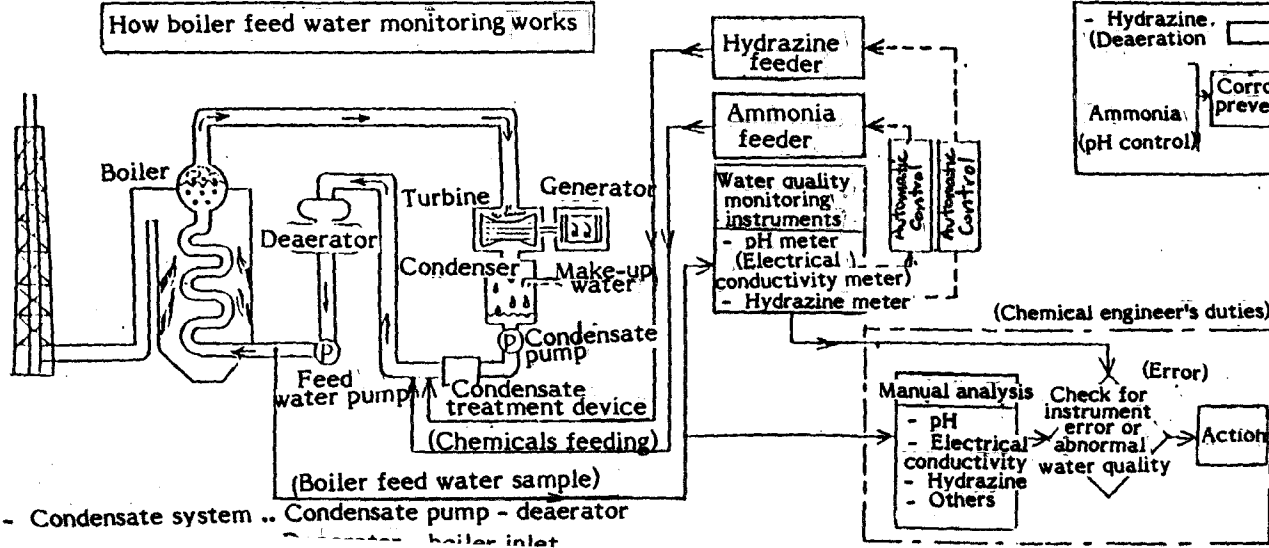
Objective

To narrow the width of variations in the hydrazine concentration.

Theme

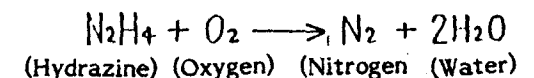
Improvement of Control Methods Regarding the Hydrazine Concentration in Boiler Feed water

How boiler feed water monitoring works



Explanation of hydrazine feeding

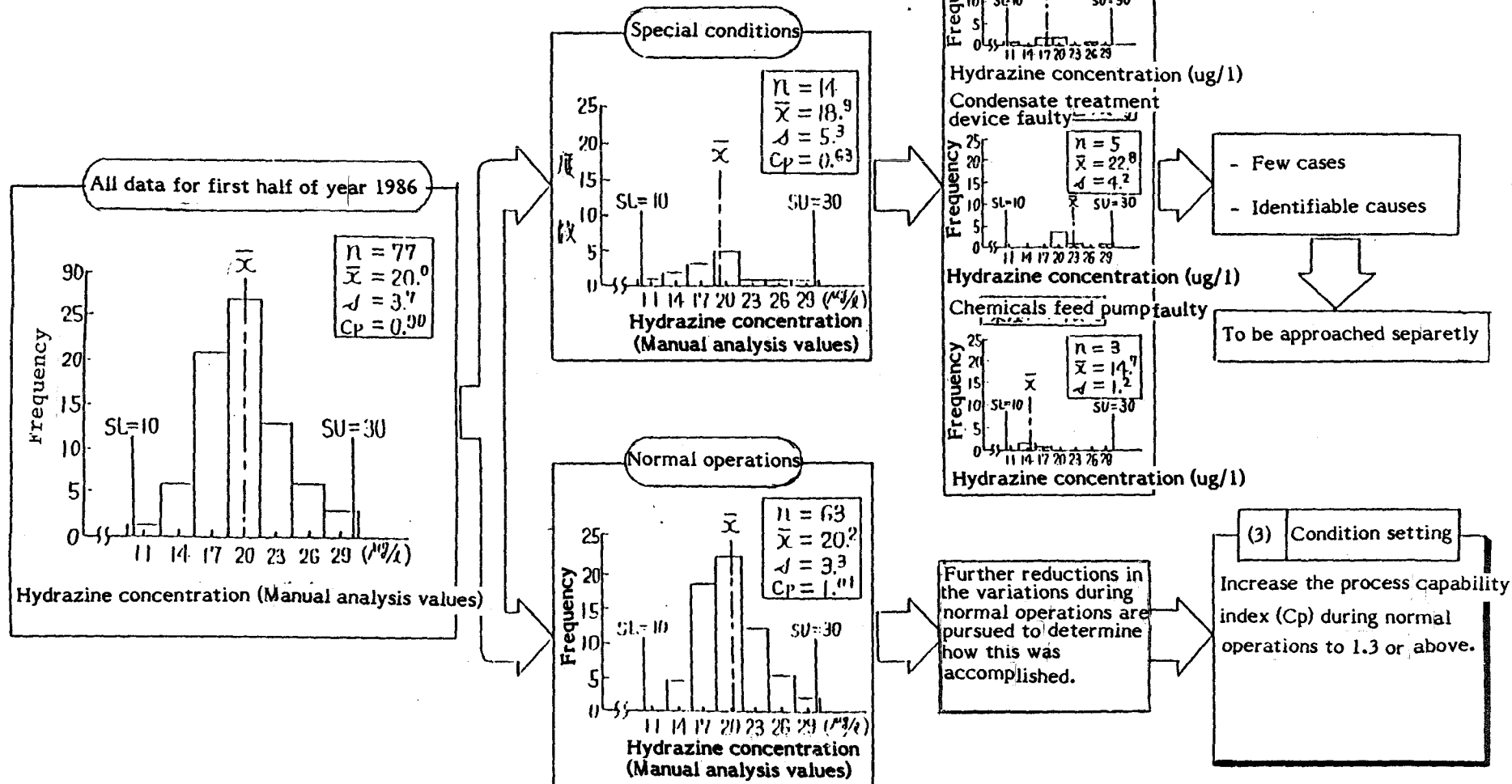
Because the presence of oxygen transmitted from the make-up water could corrode the piping system, remove the dissolved oxygen with hydrazine (N_2H_4) to prevent corrosion.



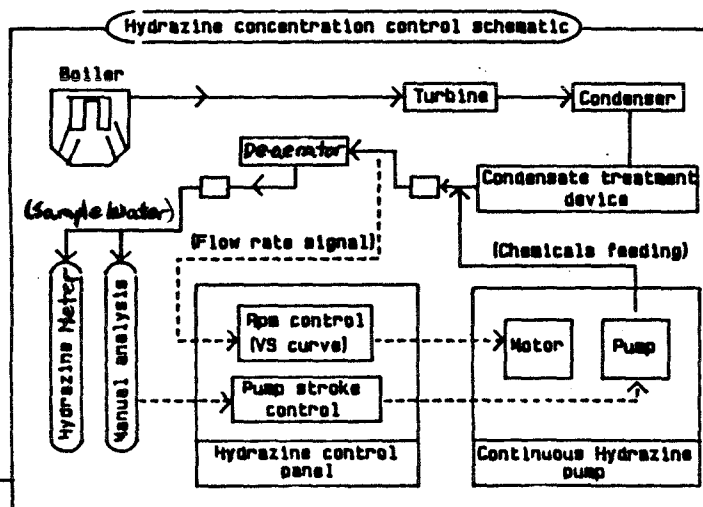
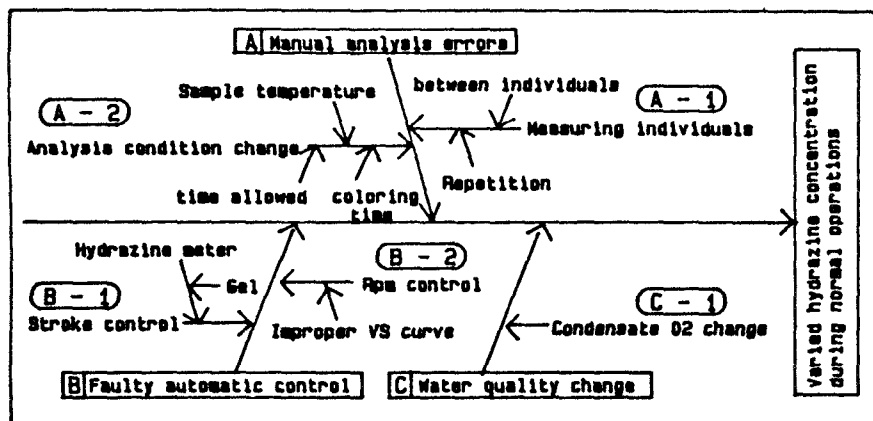
Hydrazine is fed into the condensate system in the quantity necessary to maintain a given concentration or higher in the feed water system (control limit 10-30 $\mu g/l$).

Understanding the Current Situation

All the data on the hydrazine concentration for the first half of the year 1986 is stratified into the periods of special conditions affecting the hydrazine concentration and periods of normal operations on the basis of chemistry-related reports and journals.



14) Factor Analysis



Rpm control

The number of meter revolutions is controlled to adjust the quantity of hydrazine feed for an essentially constant hydrazine concentration in the presence of transient condensate flow rate (load) changes.

VS curve: Program that converts condensate flow rate signals into motor rpm.

The quantity of hydrazine is gradually reduced as it reacts with dissolved oxygen in the condensate.

Stroke control

The concentration of residual hydrazine in the feed water is measured with a hydrazine meter and deviations from 20 ug/l (control limit) are corrected by pump strokes.

A Determination of manual analysis errors

A-1 Errors dependent on measuring individuals.

The same sample is measured by five measuring individuals three times each.

Results of hydrazine manual analysis error determination

Repetition	First	Second	Third	Range (R)	Mean
A ₁	20.5	20.1	19.1	1.5	20.06
A ₂	20.8	20.1	19.6	1.0	20.26
A ₃	20.6	20.1	20.5	0.2	20.60
A ₄	20.5	21.0	20.8	0.5	20.76
A ₅	20.5	19.7	20.3	1.5	20.16

The numbers denote the order of measurement (unit: ug/l)

Analysis result

There are no differences between individuals and repeatability errors are extremely small.

A-2 Errors due to changing analysis conditions

The same sample is measured with regard to three factors and three levels each.

Factor	Level	1	2	3
(A) Time allowed (min)		20	40	60
(B) Sample temperature (°C)		20	25	30
(C) Coloring time (min)		10	35	60

Assignments in an orthogonal array table, and testing results

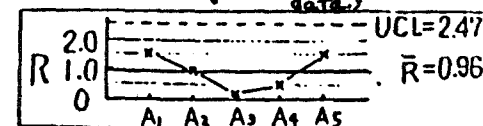
Row	1 (A)	2 (B)	3 (C)	$\bar{x}$
1	1	1	1	22.0
2	2	3	1	20.4
3	1	2	2	21.3

(Unit: ug/l)

Analysis result

While the analysis error of the hydrazine concentration is influenced by the sample temperature, its effect is as small as around 1 ug/l at working temperatures (22-28°C).

R chart (confirming non-existence of abnormal data)



Preparation of an analysis of variance table

Factor	Sum of squares	Degrees of freedom	Unbiased variance	Variance ratio	Expected value of unbiased variance
Between individuals (A)	1.06	4	0.265	0.722	$\sigma_e^2 + 3\sigma_A^2$
Repetition (e)	3.67	10	0.367	—	σ_e^2
Total (T)	4.73	14	—	—	—

$$F_0 = 0.722 < F_{10}(0.05) = 3.48$$

Size of analysis accuracy

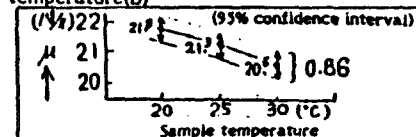
Coefficient of variation prescribed by our regulations (dependent on concentration)	3~10%
Coefficient of variation obtained from experiments	3%

Variance analysis results

Factor	Sum of squares	Degrees of freedom	Unbiased variance	Variance ratio	Expected value of unbiased variance
Time allowed (A)	0.11	2	0.055	1.83	$\sigma_e^2 + 3\sigma_A^2$
Sample temperature (B)	8.4	2	0.97	32.33	$\sigma_A^2 + 3\sigma_B^2$
Coloring time (C)	0.01	2	0.005	0.17	$\sigma_e^2 + 3\sigma_C^2$
Error (e)	0.06	2	0.03	—	σ_e^2
Total (T)	2.12	8	—	—	—

*Significant (5% $F_{12}(0.05) = 19.0$)

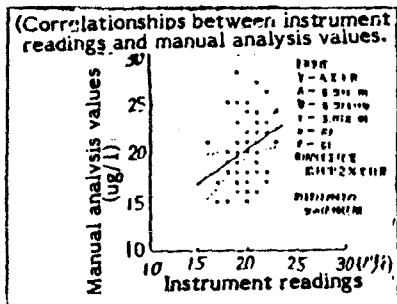
Estimation of the population mean of sample temperature (B)



B Determination of faulty automatic control

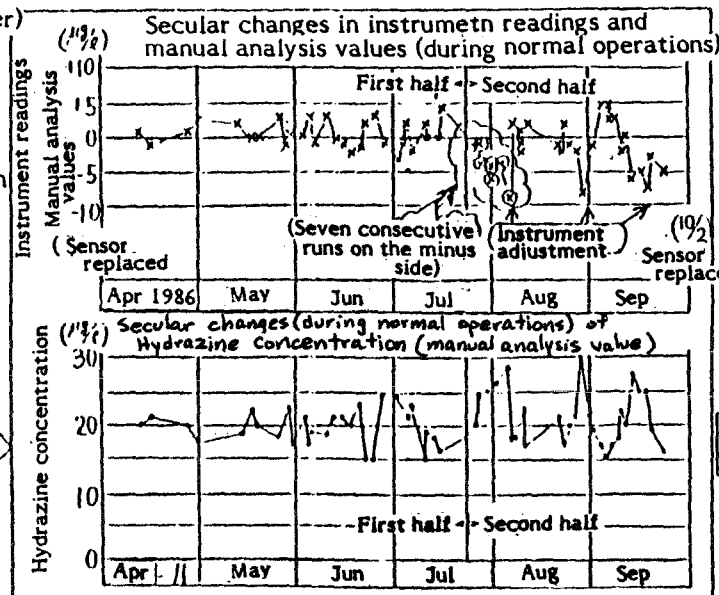
B-1 Faulty stroke control (Faulty hydrazine meter)

Comparative studies were made of the readings of the hydrazine meter during normal operations and manual analysis values for the first half of the year 1986.



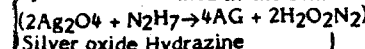
The weak correlation between manual analysis values and instrument readings is suspicious.

Graph secular changes



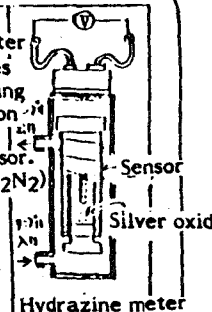
Principles of operation of the hydrazine meter

The hydrazine meter measures the electromotive force resulting from the oxidation and reduction of silver oxide (Ag_2O) and hydrazine contained in the sensor.



Silver oxide Hydrazine

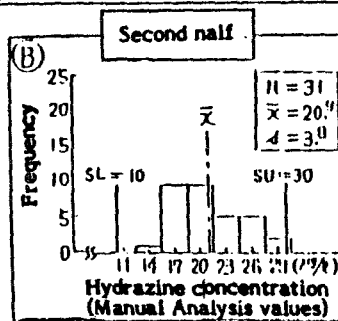
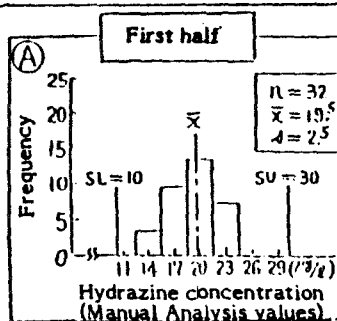
The instrument was adjusted as the sensor deteriorated. When the sensor deteriorated to the extent of disabling instrument adjustment, it was replaced.



Differences appeared to exist in the variation of the hydrazine concentration before and after the instrument showed outlying observations.

Stratify the data into the first and second half of the year 1986.

Stratification was performed before and after seven consecutive runs of the differences between instrument readings and manual analysis values on the minus side.

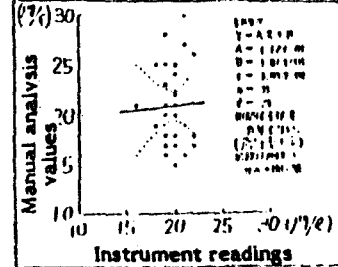
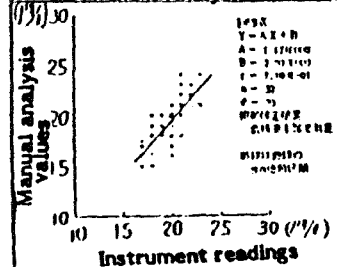


$H_0: \sigma_A^2 = \sigma_B^2$
 $H_1: \sigma_A^2 < \sigma_B^2$
 $F_0 = 2.29 > F_{31}(0.05) = 1.84$
 Significant as a result of the F test.

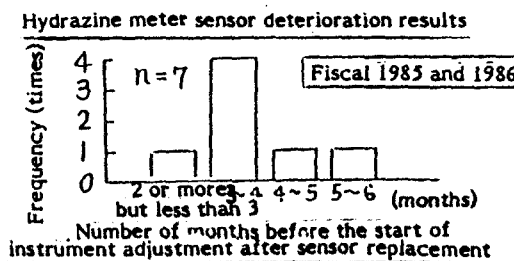
Differences existed between the data for the first half of the year 1986 and that for the last half (the former being more varied)

Analysis result

The sensor in the hydrazine meter becomes unable to precisely measure the hydrazine concentration about four months after replacement.

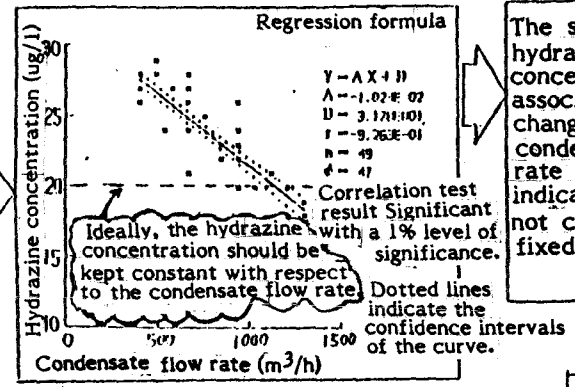
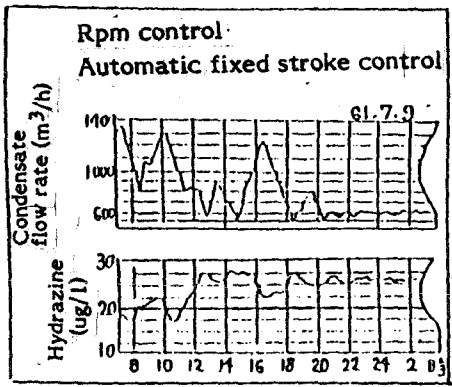


Correlation test result
 First half: Significant with a 1% level of significance.
 Second half: Not significant with a 5% level of significance.



B-2 Faulty rpm control

The relationship between the condensate flow rate (load) and the hydrazine concentration was examined to gain an understanding of the status of rpm control.



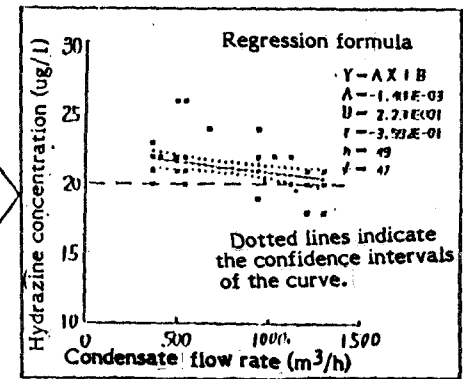
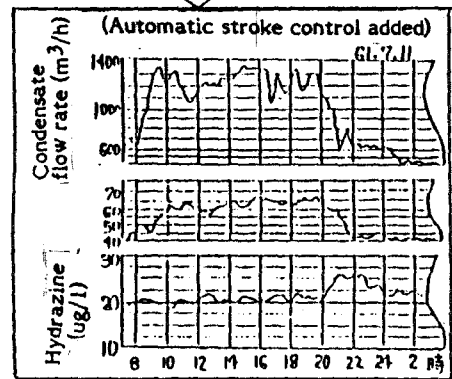
The slope of the hydrazine concentration associated with changes in the condensate flow rate is marked, indicating that it is not controlled at a fixed level.

Analysis result

The VS curve (a program that converts condensate flow rate) signals into motor rpms) has not been set properly.

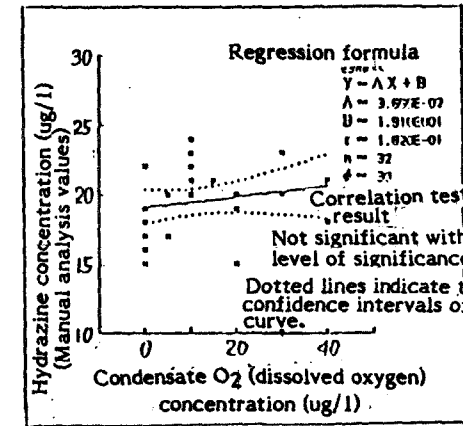
Even if the VS curve is somewhat inappropriate, stroke control corrects the hydrazine concentration for a fixed level.

Check the amount of correction by stroke control



C Water quality changes

C-1 Condensate O₂ change (for the first half of normal operations)



Analysis result

No correlations existed between the O₂ (dissolved oxygen) concentration of the condensate and the feed water hydrazine, indicating that the hydrazine concentration was unaffected by the condensate O₂ concentration.

(The hydrazine concentration was correctable by stroke control.)

- Variance analysis results

	Sum of squares	Degrees of freedom	Unbiased variance	Variance ratio
Variations due to regression	14.77	1	14.77	6.96
Residual	99.75	47	2.12	-
Total	114.52	48	-	-

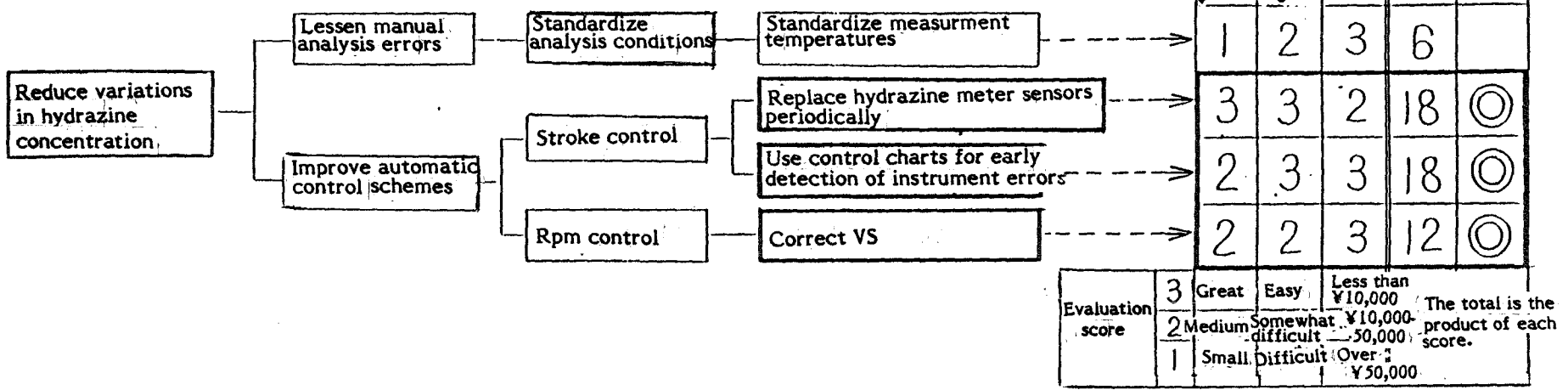
*Significant (5%)

$$F_0 = 6.96 > F_{47}(0.05) = 4.05$$

Analysis result

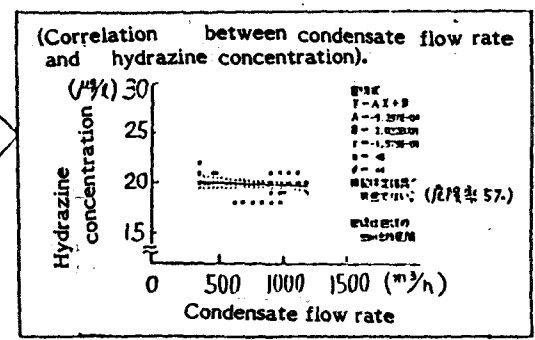
The slope associated with rpm control is so marked that the hydrazine concentration cannot be fully corrected.

5 Discussion of Countermeasures



6 Implementation of Countermeasures

- Countermeasure 1: Replace the hydrazine meter sensor periodically every three months (practiced on a trial basis since September, 1986).
- Countermeasure 2: Due to large variations in the period until the deterioration of the hydrazine meter sensor, control difference between manual analysis values and instrument readings by the use of control charts (practiced since Sept 1986).
- Countermeasure 3: A new VS curve was created from result data and pump performance curves and its modifications were requested from the instrumentation clerk (on September 1986).

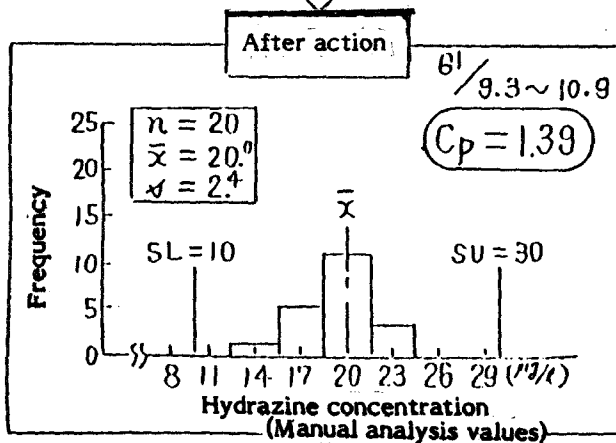
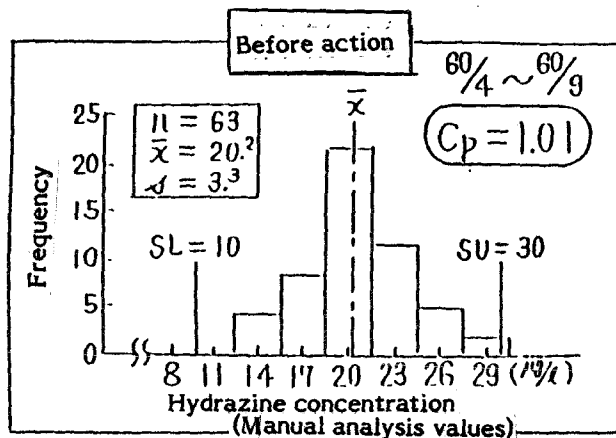


Not significant with a 5% level of significance.

Variations in the hydrazine contraction associated with changes in the condensate flow rate have been eliminated by rpm control alone.

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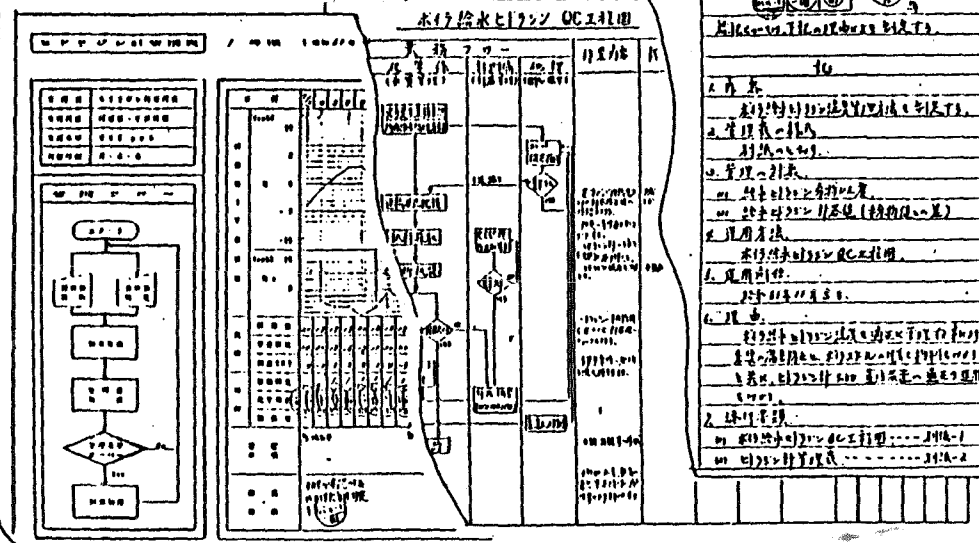
Effect Verification



8

Standardization

Procedures for controlling the hydrazine concentration of boiler feed water incorporating QC schedule drawings were established as in-house regulations and standardized (on November 5, 1986).



9

Future Tasks

Continuing studies will be made to examine the suitability of the current hydrazine meter sensor replacement interval of three months.