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Analysis of Work Environment Data from Three Army Field Stations

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U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(Formerly National Bureau of Standards)
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U.S. DEPARTMENT OF COMMERCE
C. William Verity, Secretary

NATIONAL INSTITUTE OF STANDARDS
AND TECHNOLOGY
Ernest Ambler, Director

Abstract

Data from a detailed evaluation of environmental conditions in three U.S. Army field stations are presented. Three field stations were evaluated: Kunia, Hawaii; Augsburg, West Germany; and Berlin, West Germany. Results from a questionnaire administered to over 600 people at all sites in three job types (operator, analyst, and administrative/other) are given which indicate major concerns with conditions such as temperature, lighting, space, furniture, equipment functioning, and general environmental quality. Physical data obtained from measurements of over 270 workstations indicated the presence of cold temperatures, low light levels, reduced VDT screen contrast, glare, and distracting noises. The report provides the basic data which support the concerns expressed by Headquarters; namely, that field station personnel perform their jobs under conditions likely to impair their effectiveness. Suggestions for improving conditions are given in a companion report by Rubin and Collins.

Keywords:

Automation, contrast, environmental assessment, indoor air quality, lighting, luminance, noise, post-occupancy evaluation, temperature, VDT's

Foreword

This report is the third and final report in a series of reports by the National Bureau of Standards (now the National Institute of Standards and Technology) on the evaluation of conditions in U.S. Army field stations. It was supported by the U.S. Army Intelligence and Security Command (USAINSCOM) under contract No. A73050-0134-87.

Acknowledgements

The authors wish to thank all the people at the field stations and at headquarters who cooperated with us in the course of this research. Without their willing and enthusiastic help, this report would not have been possible.

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1. Introduction

Many military and civilian employees of the U.S. Army are required to work in an office environment often unlike those experienced by most other workers. Their working environments are characterized by windowless spaces, highly automated equipment, and work tasks requiring utmost concentration. These conditions have led to employee complaints concerning lighting, air quality, thermal environmental conditions, lack of view to the outside, and rotating work schedules that add stress to an already complex work situation.

Because the working conditions described above are believed to detract from job performance, the U.S. Army sought assistance in identifying the problems and developing guidelines for suggesting environmental and other changes to ameliorate the problems. Solutions to the problems are complex, because many interdependent conditions impact the work environment of the individual. These conditions are based on the work performed, and environmental conditions, as well as design, technological, ergonomic, organizational, and personal issues.

1.1 Technical Approach

The study was performed in two phases. The first consisted of a literature search, interviews with experts, and planning and conducting a pilot study at two field sites. Results from the initial evaluation are presented in a report by Rubin and Collins (1987). The second phase was a comprehensive field investigation at three sites, including in-depth interviews with personnel, a detailed questionnaire survey, and field measurements of lighting, air quality, noise and other environmental attributes. Two reports describe results from the study. The present one provides physical data on the conditions at the field stations as well as the occupants' reactions to them, while a companion report by Rubin and Collins (1988) describes the highlights of the results presented here, as well as suggestions and recommendations for improving conditions.

1.2 Field Measurements

The environmental assessment reported in the present report involved two major sources of data collection. The first was a determination of the user response to conditions at the field stations, while the second involved detailed physical measurements of the same conditions. User response data were obtained in several ways: in-depth personal interviews with key people; responses to a detailed environmental questionnaire from a representative sample of site personnel; and observations of working environments and jobs. Physical data included measurements of light levels and contrasts, noise, temperature, humidity, and (limited) air quality, as well as observations of furniture condition, colors used in the facilities, and noise distractions.

2. Experimental Procedures

Three field stations were examined in detail; Kunia, Hawaii; Berlin, Germany; and Augsburg, Germany. The activities performed and the general environmental settings at these locations are representative of similar installations throughout the world. The three stations visited were all windowless facilities, with Kunia actually being underground.

2.1 Questionnaire Survey

Detailed environmental questionnaires were distributed to a sample of the people at all sites. (A copy of the questionnaire appears in appendix A.) The individuals sampled were selected on the basis of the activities performed and their location. For convenience, three groups of occupants were identified based on the primary tasks performed: operators (who collect information), analysts, and administrative, (which also includes clerical and maintenance).

A breakdown of the questionnaire sample by location is as follows:

	Operators	Analysts	Admin	Total
Kunia	154 (56%)	77 (28%)	42 (15%)	273
Augsburg	124 (57%)	52 (24%)	41 (19%)	217
Berlin	69 (53%)	32 (24%)	30 (23%)	131
Total	347	161	113	621

2.2 Physical Measurements

Concurrent with the questionnaire survey, measurements of several physical environmental characteristics were made. These included lighting measures (luminance and illuminance), noise, temperature, humidity, air flow and physical dimensions of workstations. Other assessments included color, sound intrusiveness, chair and panel design and quality, furnishings and wall type, carpets and personalization of space. (The form used in collecting these data is included in Appendix A.) While the physical data are presented in detail in section 5, selected findings will be discussed as they relate to data obtained from the occupants with the questionnaire.

Physical measurements were taken at a total of 279 workstations. The breakdown of measures were as follows: 62 at Berlin, 79 at Augsburg and 138 at Kunia. An earlier set of measures from Kunia was reported in Rubin and Collins (1987). The primary focus of these measures was on the lighting conditions at the workstation with a major variable being the presence or absence of VDT's. For the 279 workstations, there were 171 workstations with VDT's, and 108 without them.

3. Results from the Questionnaire

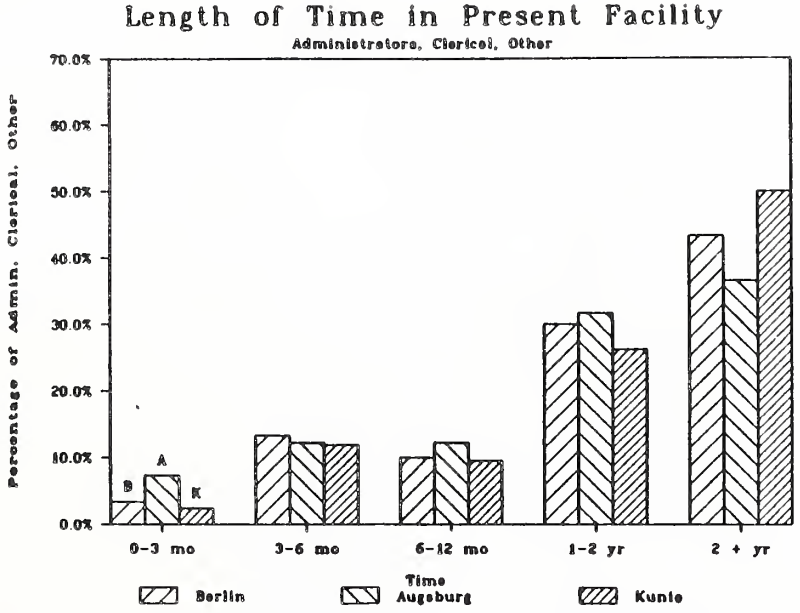
Responses to the questionnaire were graphed showing the percentage of respondents (based on the total number in the sample) on the ordinate and response to an individual questionnaire item on the abscissa. In each figure, the responses of each of three different groups, administrators, analysts, and operators, are compared for the three field stations. The three graphs have been shown in a single figure for easier comparison. Data for Berlin are always presented first, followed by those for Augsburg, and finally those for Kunia. This presentation allows a comparison of the responses for the different job categories as well as for the different field stations.

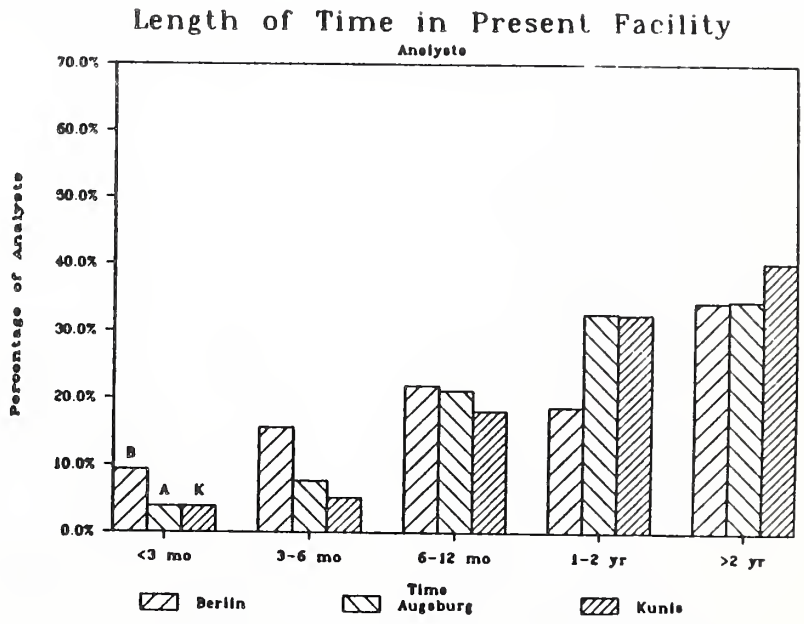
3.1 Demographic Responses

Respondents were classified according to their response to the question, "Which of the following best describes your job?". The administrative category shown on the graphs includes administrative, clerical and other, while the operator and analytical categories did not require any combination. Typically, administrative and clerical people are located in "conventional" offices, analysts are located in open plan offices, and operators are located in heavily automated offices with much VDT-like equipment. The result of this classification is to separate people doing different types of functions into different types of spaces. (The only exception to this is the maintenance and repair people who classified themselves as "other" and so are included in the administrative responses). Using this categorization, 56% of the whole sample were classified as operators, 26% as analysts, and 18% as either administrators, clerical, or other. This same breakdown was used for all 3 sites.

Figures 1 to 3 present data for the length of time that people had worked in their current facility, job, or similar facility. At all 3 field stations, about 40% of the administrators had been at the site for two or more years, 30% to 40% of the analysts had been there that long, while 60 to 70% of the operators had spent only one or more years. No clear pattern of responses emerged for the question about the length of time in the present job, with people having spent from 3 months to more than 2 years in their current job. The only exception is that 40% of the operators at Augsburg and Kunia had spent 1 to 2 years in their job. Finally more than 40% - at all sites - had spent less than 1 year in a facility like their present one.

Figure 4 demonstrates that the vast majority of the sample, 70 to 80%, was male, while figure 5 demonstrates that administrators and analysts were generally between 20 and 30 years of age, but operators tended to be younger, with 40 to 55% being between 20 and 25. Figure 6 presents a breakdown of the respondents' current shift. As expected, operators were on all three shifts, although those at Kunia tended to be on days or





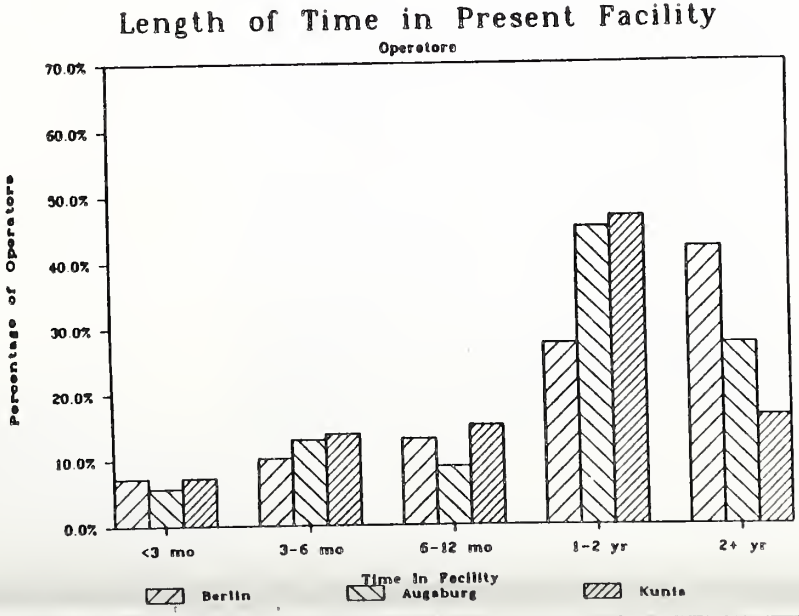
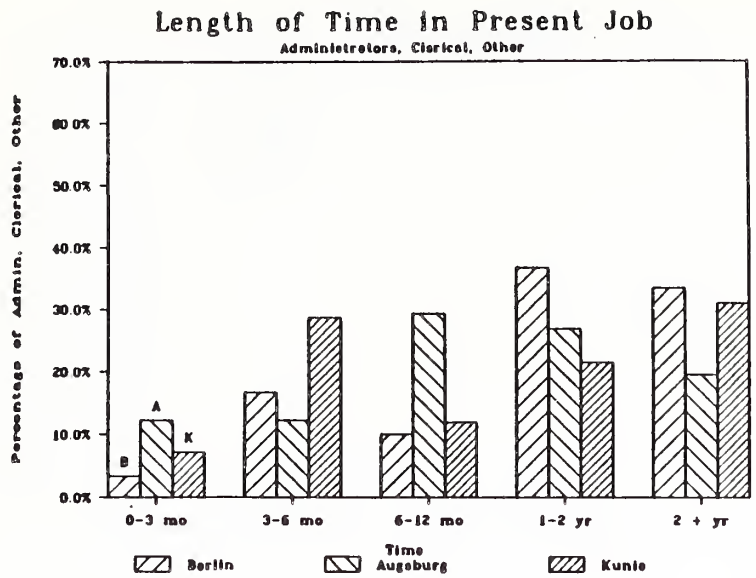
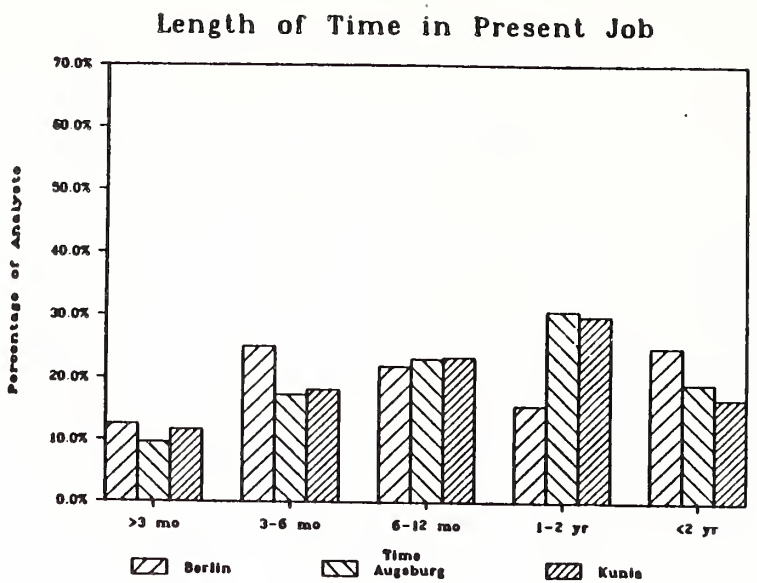


Figure 1. Length of Time in Present Facility





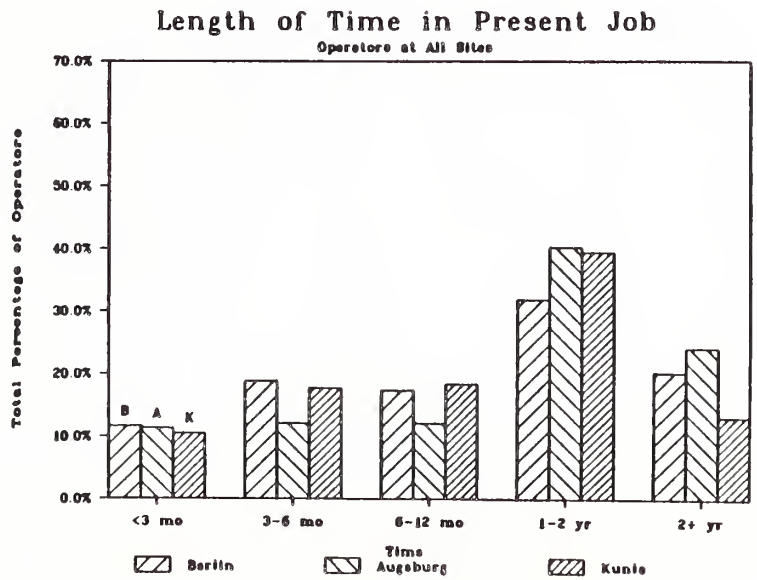
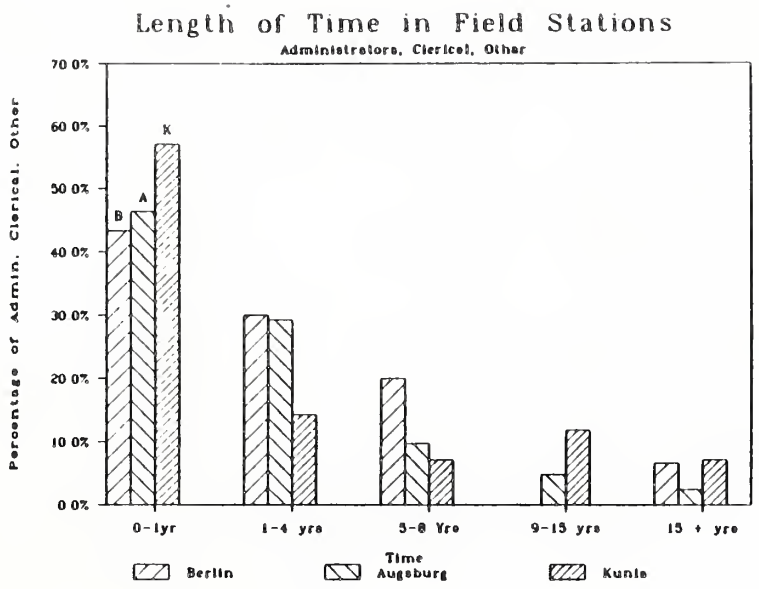
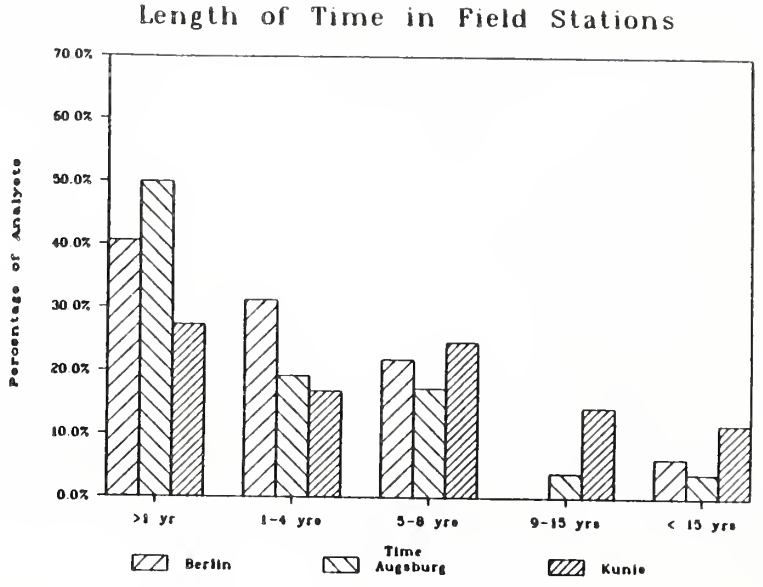


Figure 2. Length of Time in Present Job





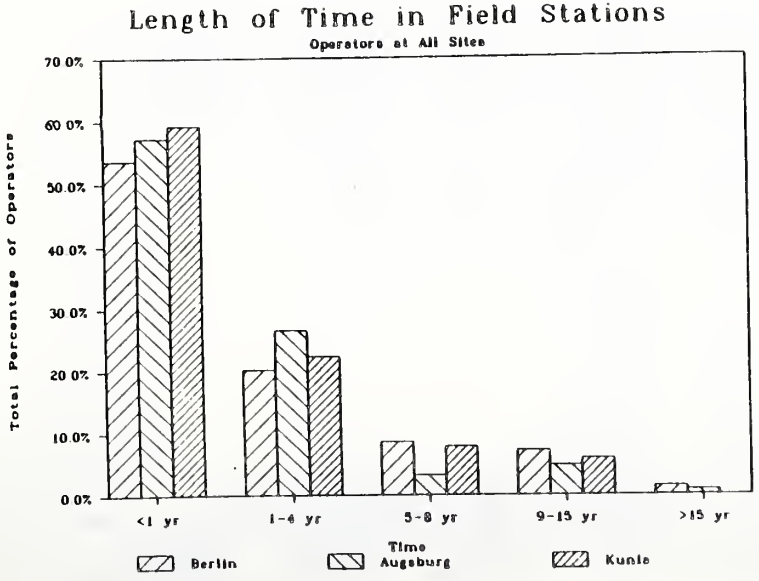
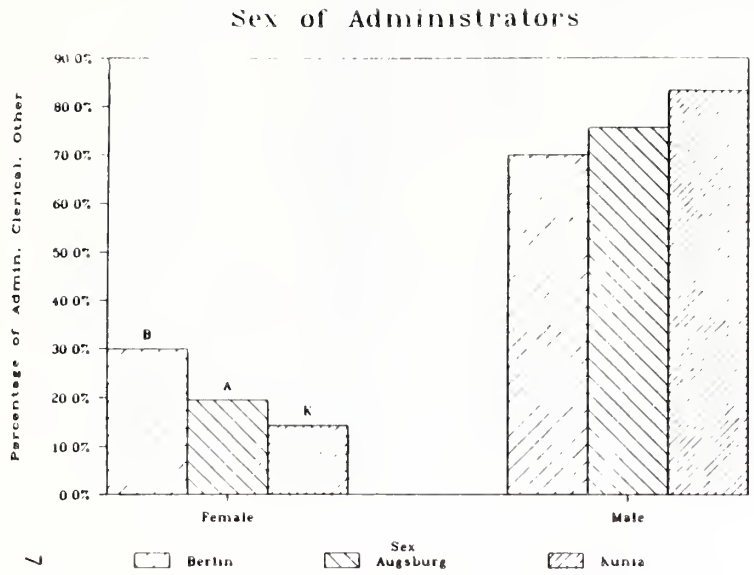
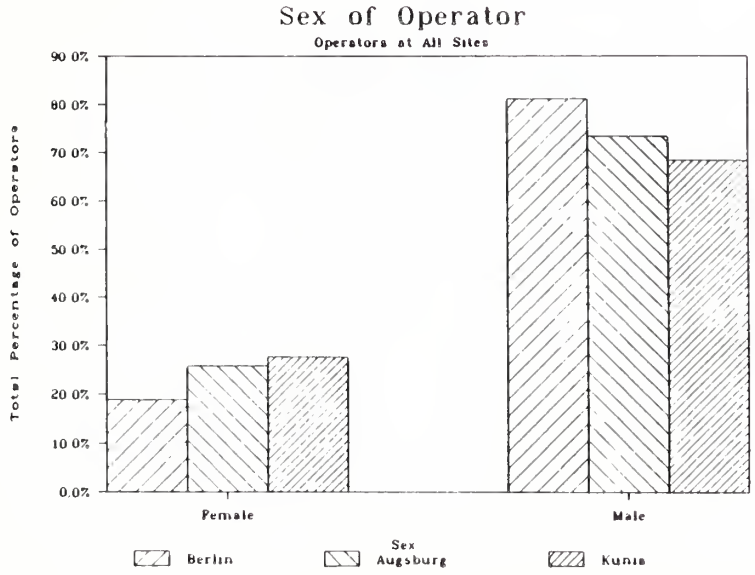


Figure 3. Number of Years Spent in Field Stations





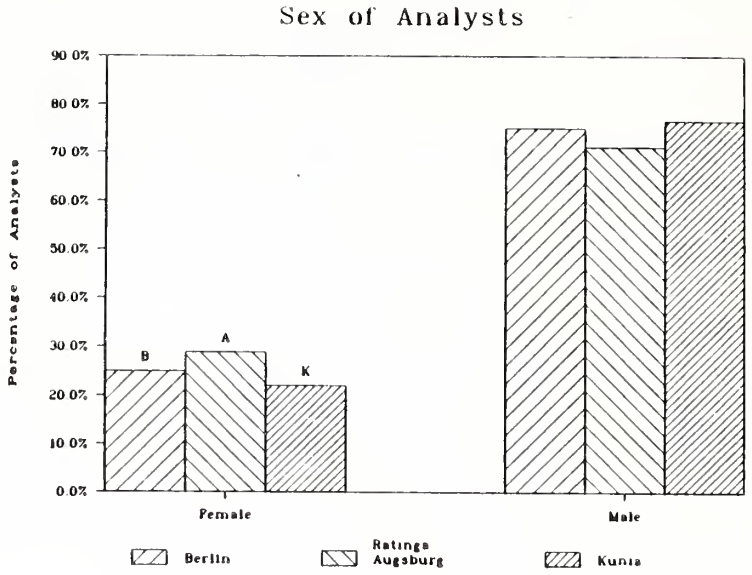
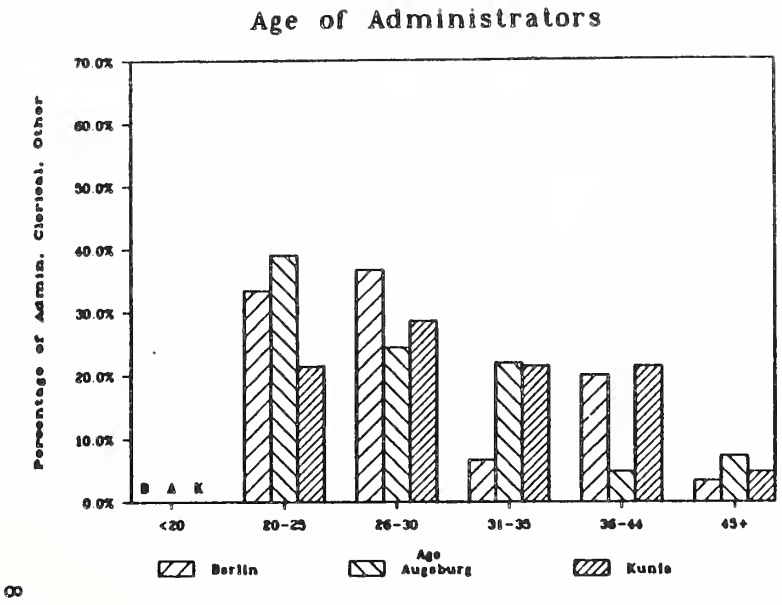
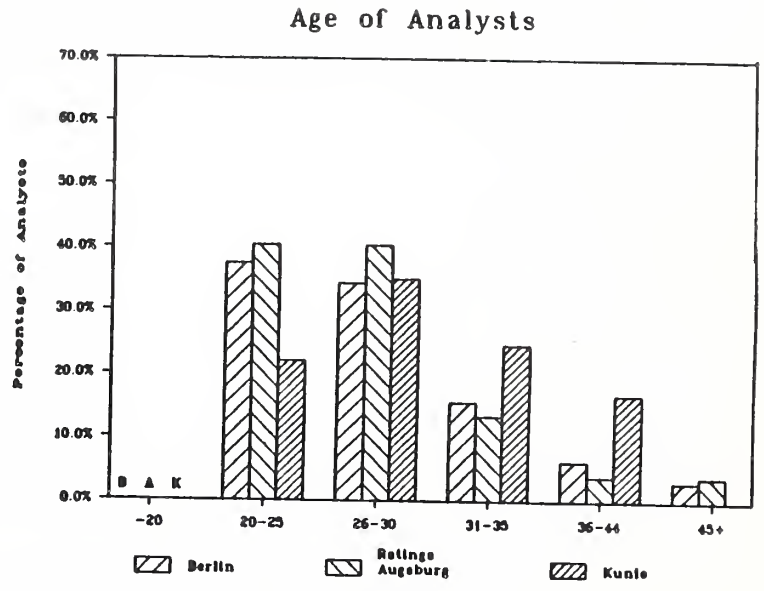


Figure 4. Percentage of Males and Females in each Job Type





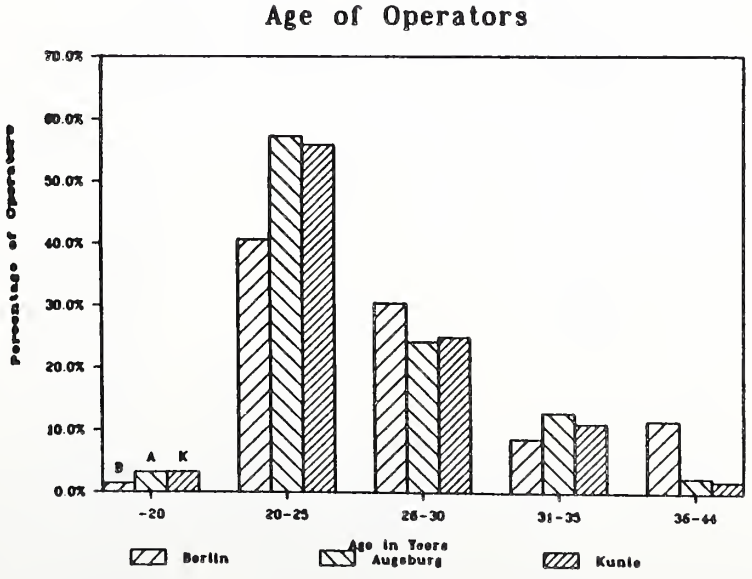
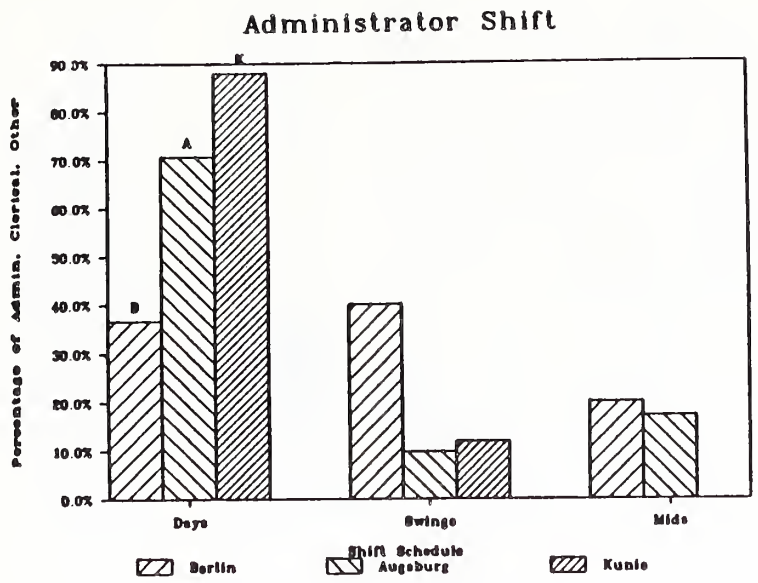
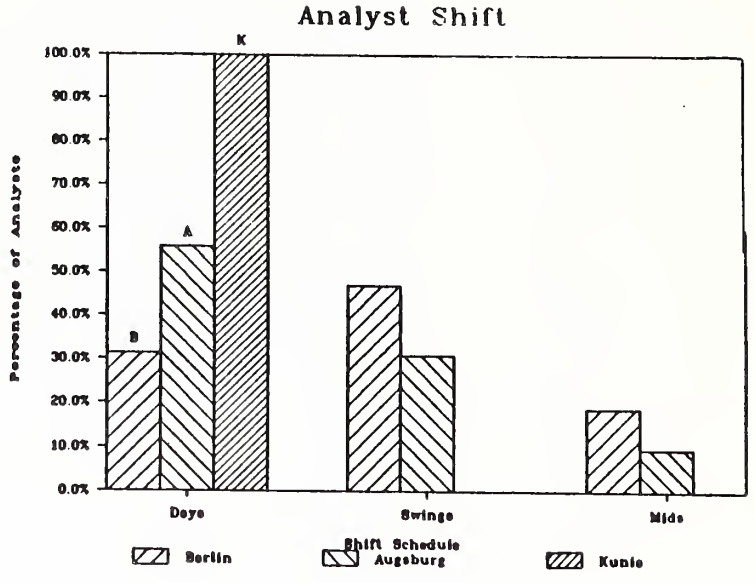


Figure 5. Distribution of Age Groups in each Job Type





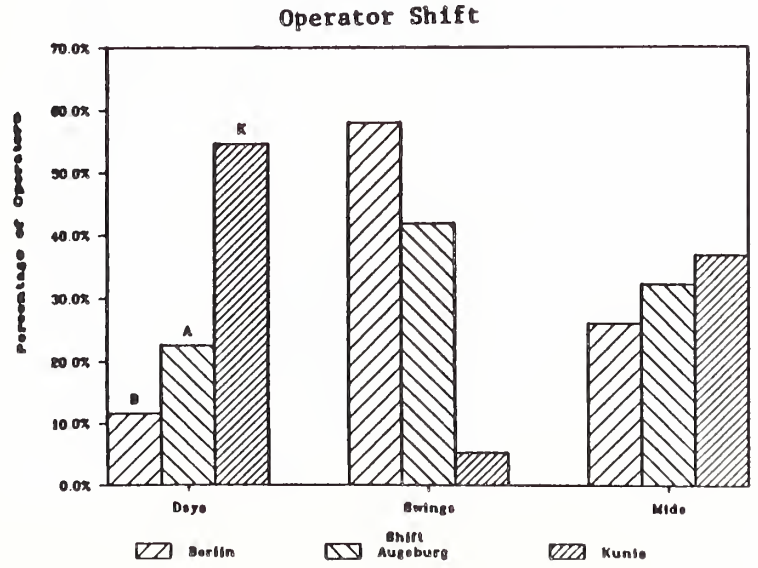


Figure 6. Percentage of People in each Job Type on each Shift Schedule

mids (overnight)[1], while most of those at Berlin and Augsburg were on swings (afternoon) or mids. At both Augsburg and Kunia, the administrators and analysts tended to be on days (all the analysts at Kunia were on days, for example) while those at Berlin were most likely to be on days or swings.

Several questions were asked about overall job satisfaction and attitudes. Figure 7 demonstrates that more than 50% of respondents from all job categories and sites considered their work very important. (In this figure a rating of 1 indicates that it is very true that the work is "important", 2 that it is "somewhat important", 3 that "it is not very true", and 4 that it is "not at all" true.) Interestingly, the feeling that the work is important was greatest for the analysts with more than 60% rating their work as "very important". Figure 8 shows that more than 50% of the whole sample considered that their work must be "very accurate", with more than 70% of analysts considering this statement to be "very true". Less than 5% of the respondents considered this statement as not true at all. Finally figure 9 demonstrates that the majority of respondents considered their jobs to be at least somewhat satisfying, with the analysts among the most satisfied. By contrast, about 15% of the operators did not find their jobs to be satisfying, while another 15 to 20% found that "it is not very true" that their job is satisfying.

3.2 Response to Thermal and Air Quality Conditions

Figures 10 to 18 present data on the respondents' views of conditions at their workstation, including temperature, ventilation and indoor air quality. In particular, figures 10 to 14, which relate to temperature, reveal that the Berlin and Augsburg field stations were generally seen as too cold - particularly in the operational areas. More than 50% of the Berlin analysts also reported being too cold. On the other hand, more than 40% of the administrators and operators at Kunia did not find cold temperatures (figure 10) to be at all bothersome. Figure 11 demonstrates that more than 60% of respondents in Berlin found the heating to be poor, as did the operators in Augsburg. Figures 12, 13, and 14 indicate that overheating was not considered to be a problem at any field station. The questionnaire was administered during late June and early July at the two German field stations when the outdoor temperatures were not especially cold. (External temperatures at Kunia in April were warmer, however, than at the two German sites.) Personnel reported being extremely cold during the winter - and needing to wear field jackets and gloves at work.

The measurements of temperature presented in section 5 for the three field stations indicate that the mean interior temperature at Berlin and Augsburg was about 70°F with a relative humidity of about 44% for Berlin and about 53% for Augsburg. The mean interior temperature at Kunia was higher - 73.5°F with a relative humidity of about 58%. Temperatures

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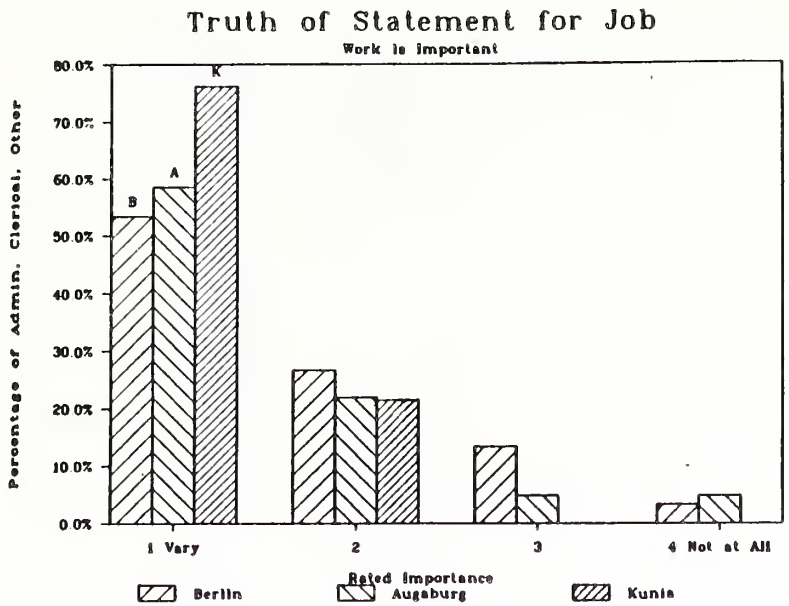
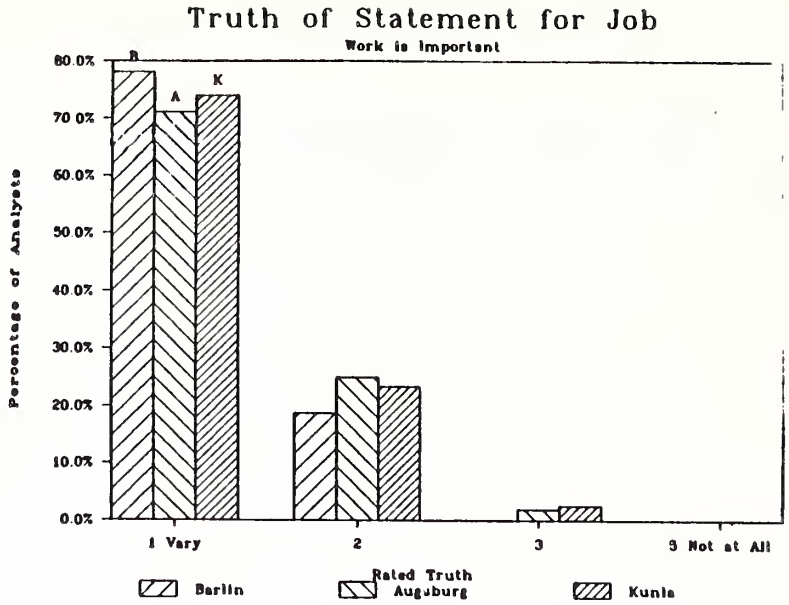
[1]Shifts include "days", typically 7am to 3pm; "swings", typically, 3pm to 11pm; and "mids", typically 11pm to 7am.





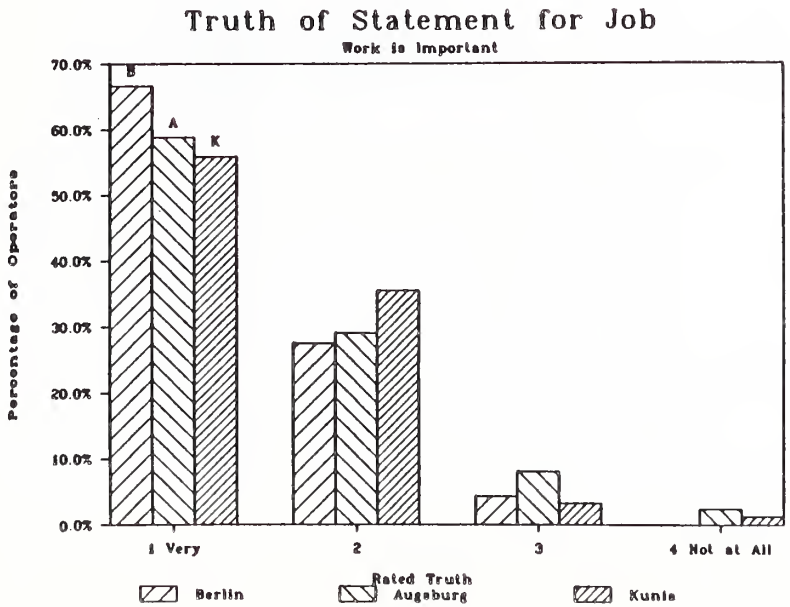
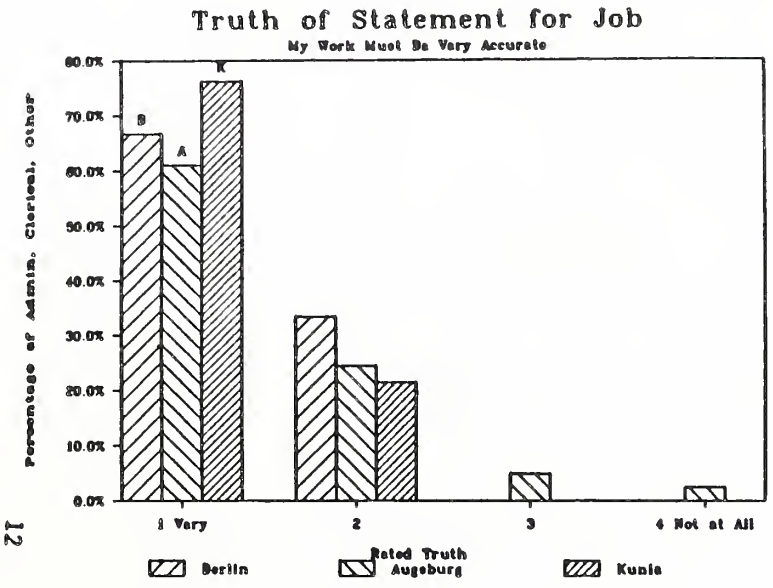
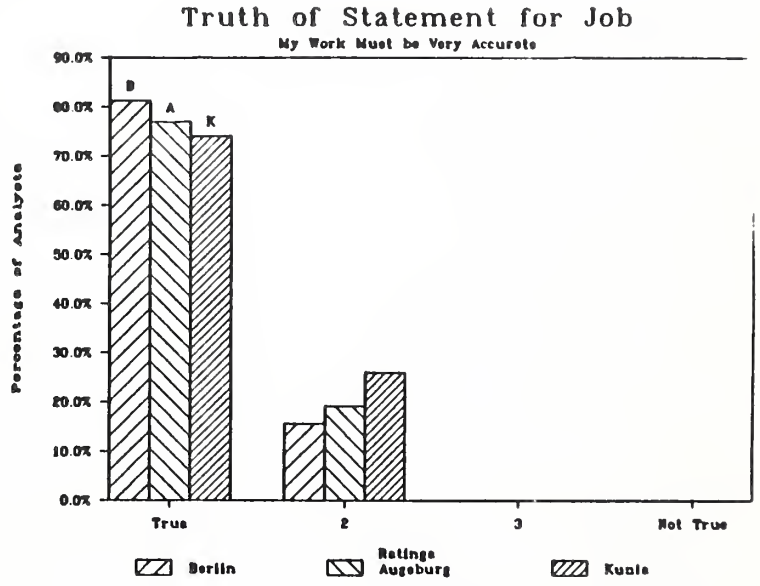


Figure 7. Percentage of People in each Job Type Indicating that their Work is Important





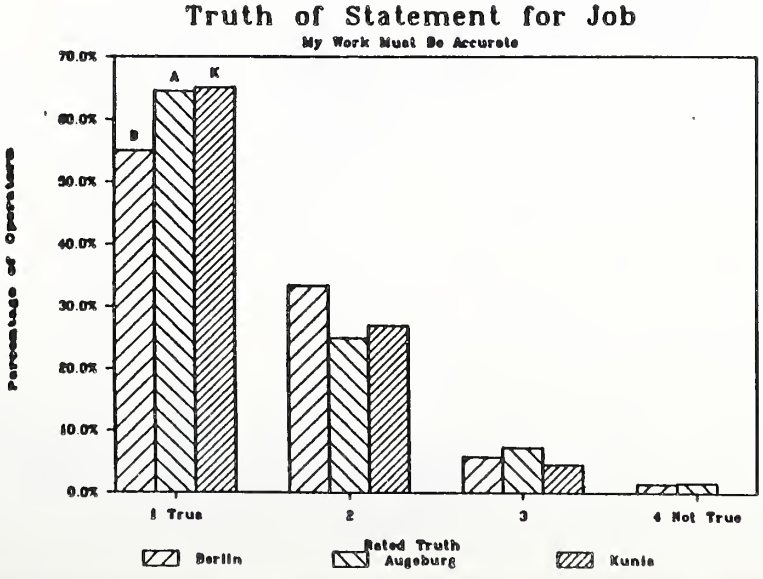
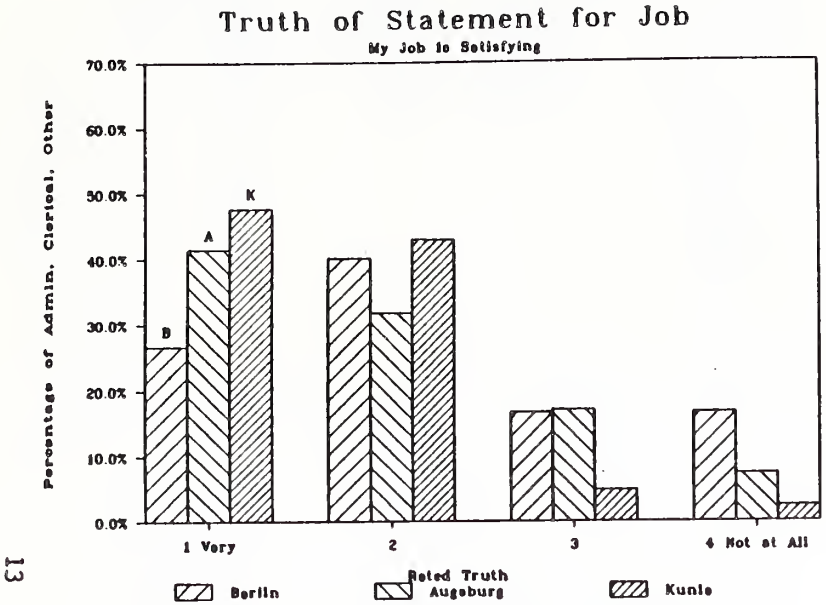
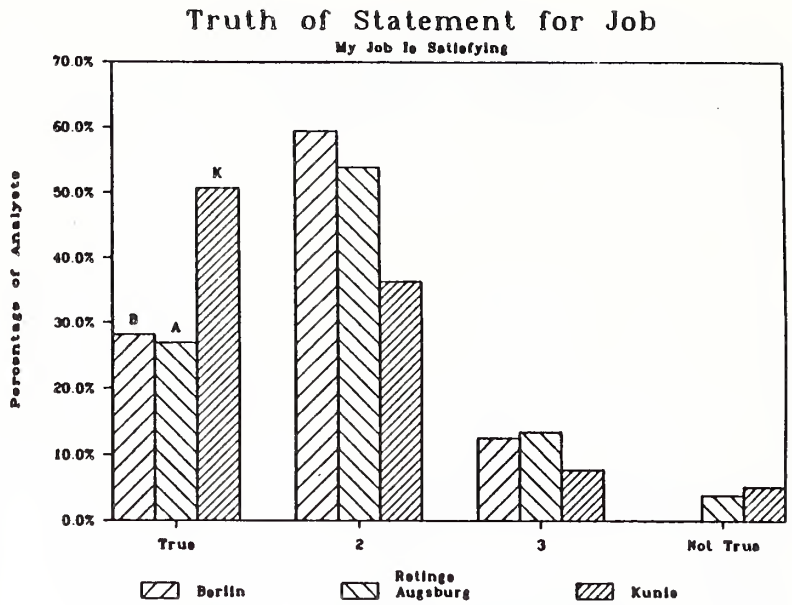


Figure 8. Percentage of People in Each Job Type Indicating how Accurate that their Work Must be





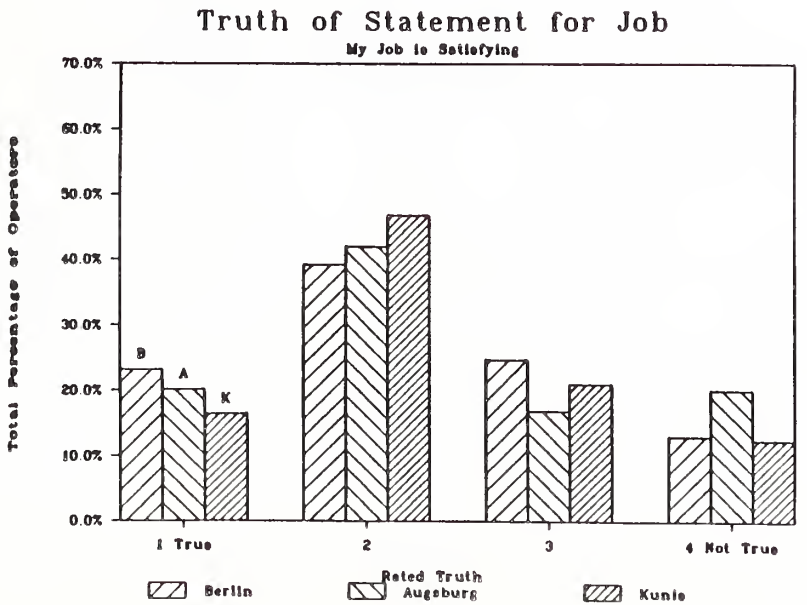
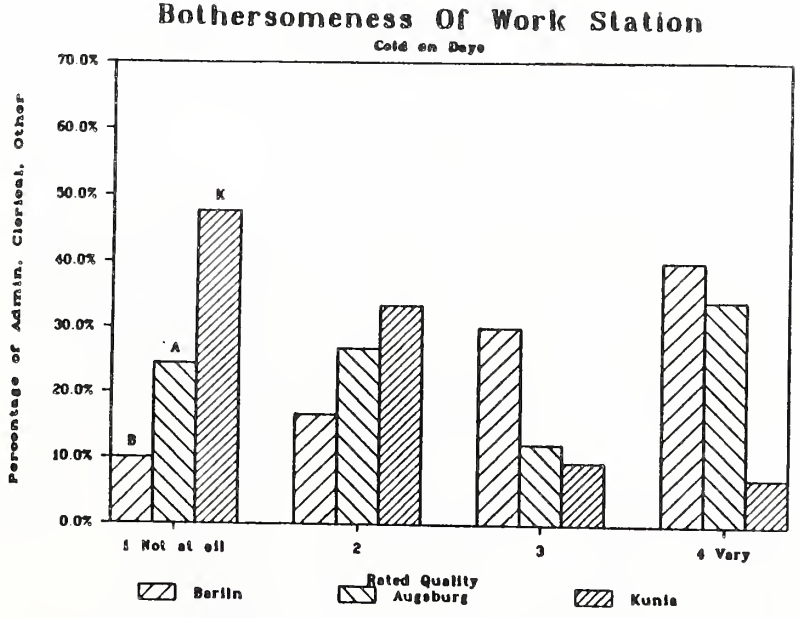
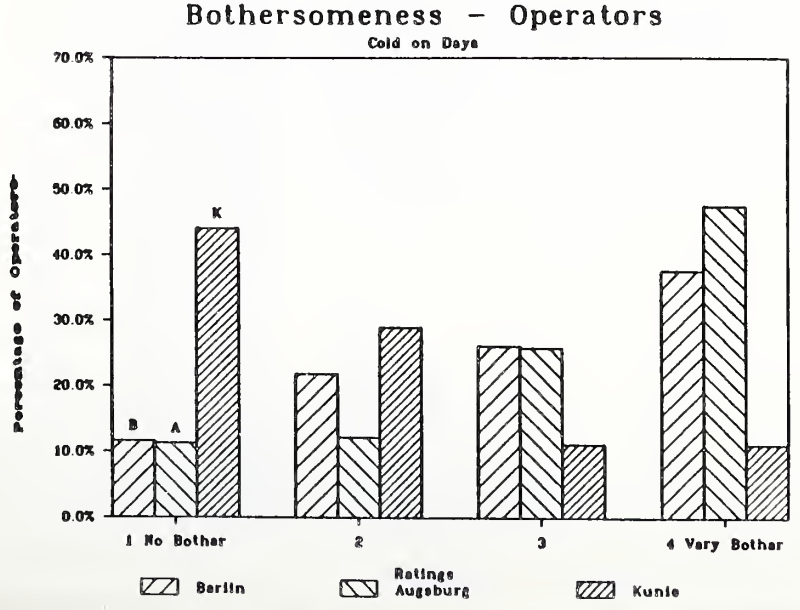


Figure 9. Degree of Satisfaction for People in each Job Type with their Job





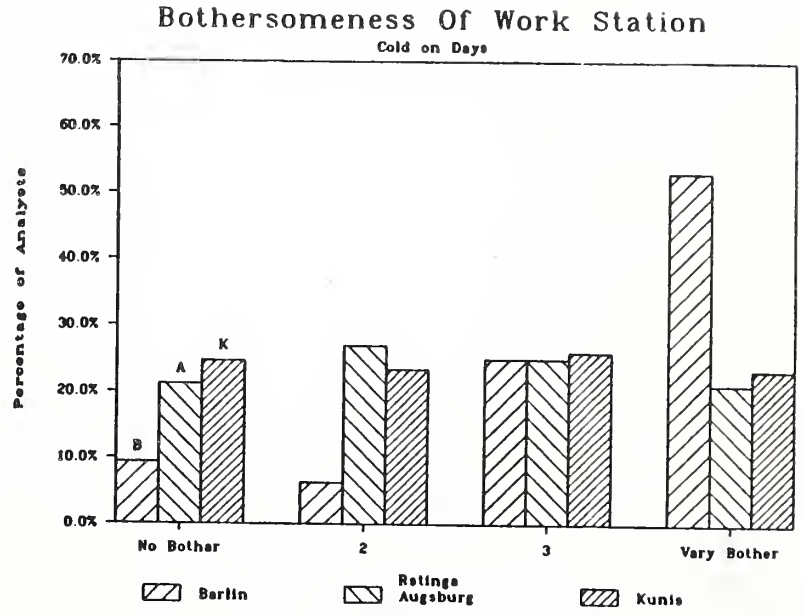
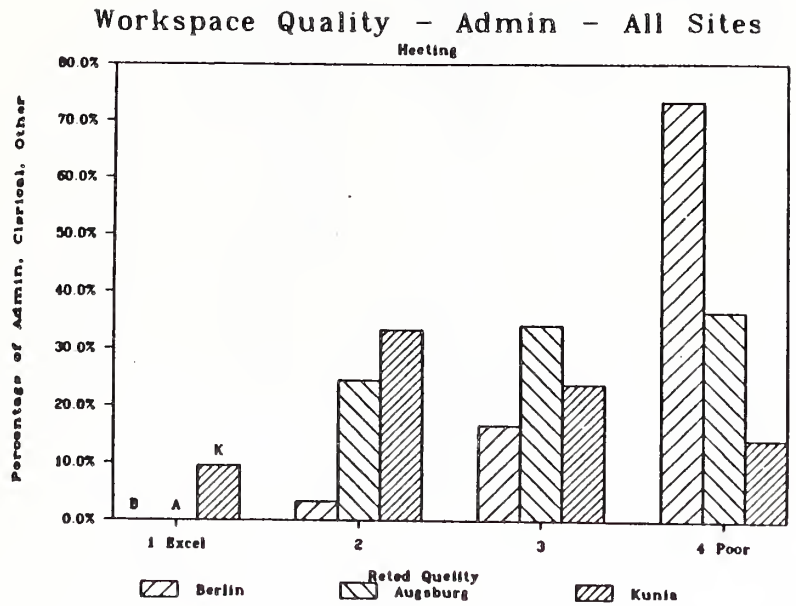
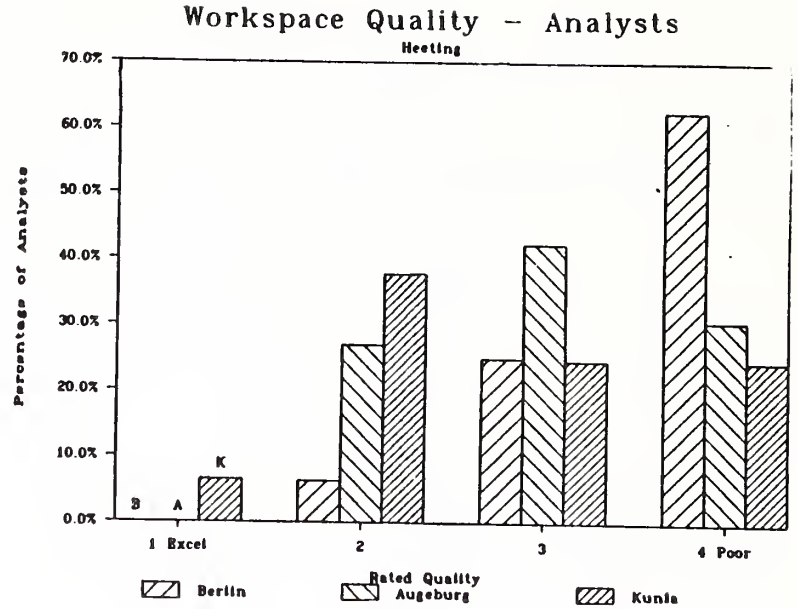


Figure 10. Percentage of People Indicating the Bothersomeness of Cold Temperatures on Days





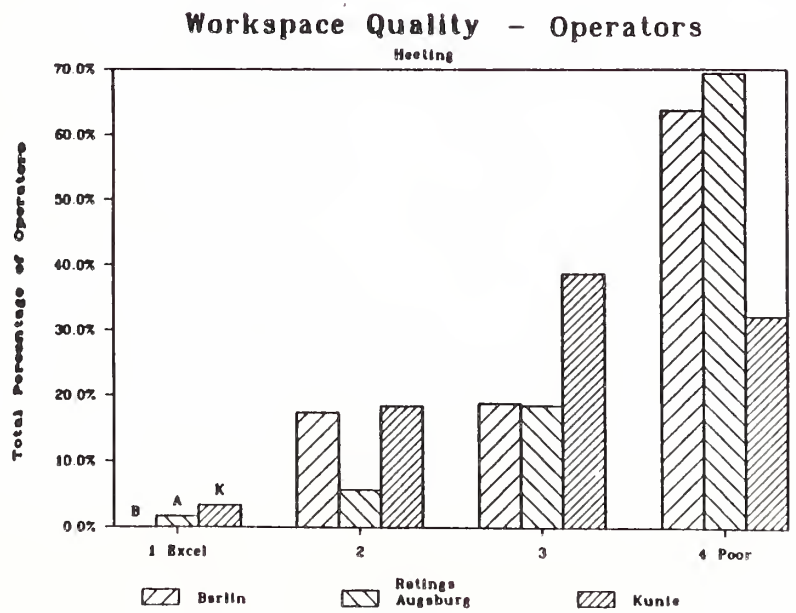
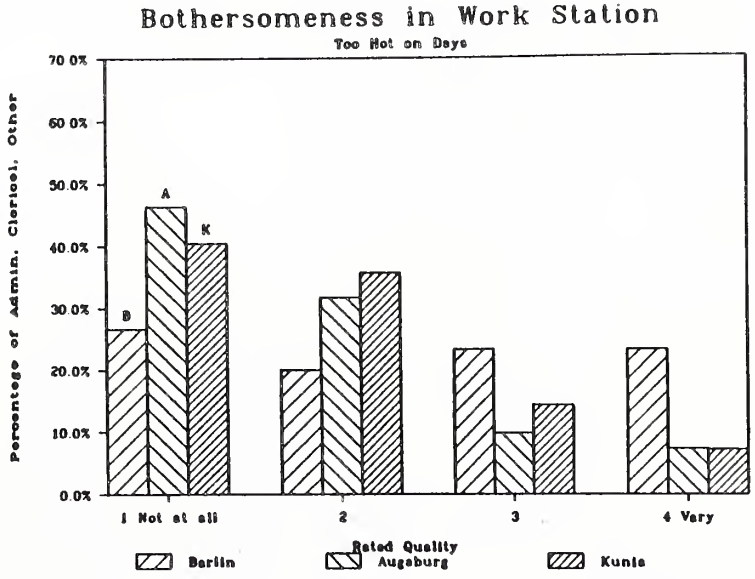
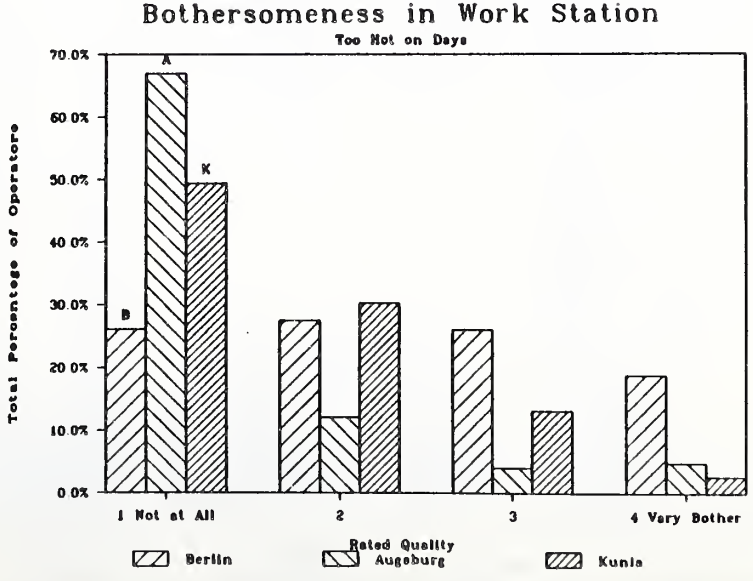


Figure 11. Percentage of People Indicating the Quality of Heating in Their Workspaces





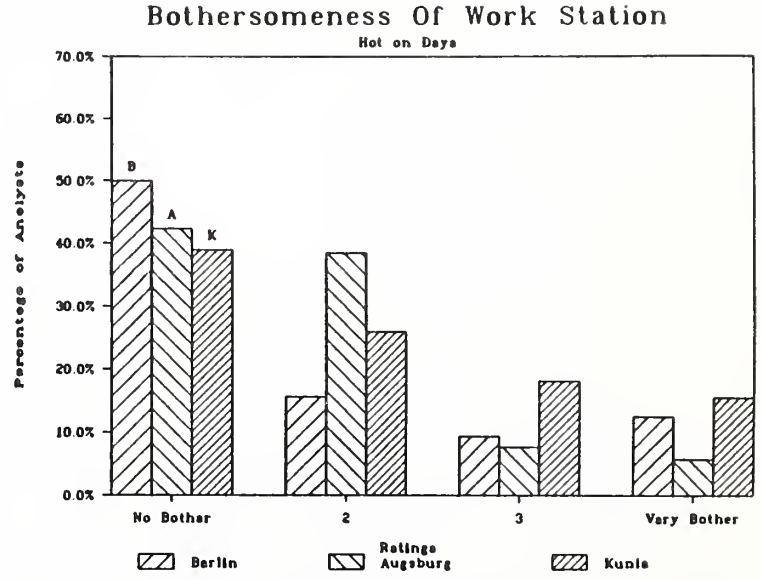
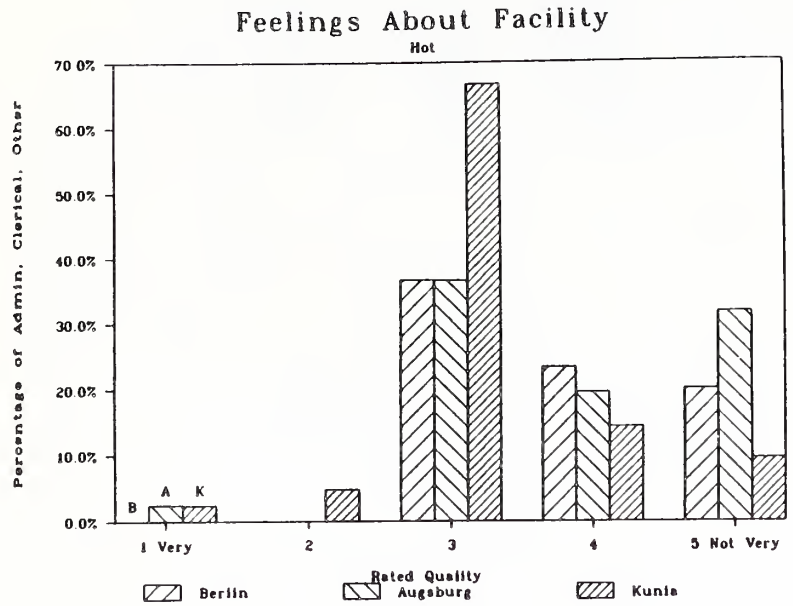
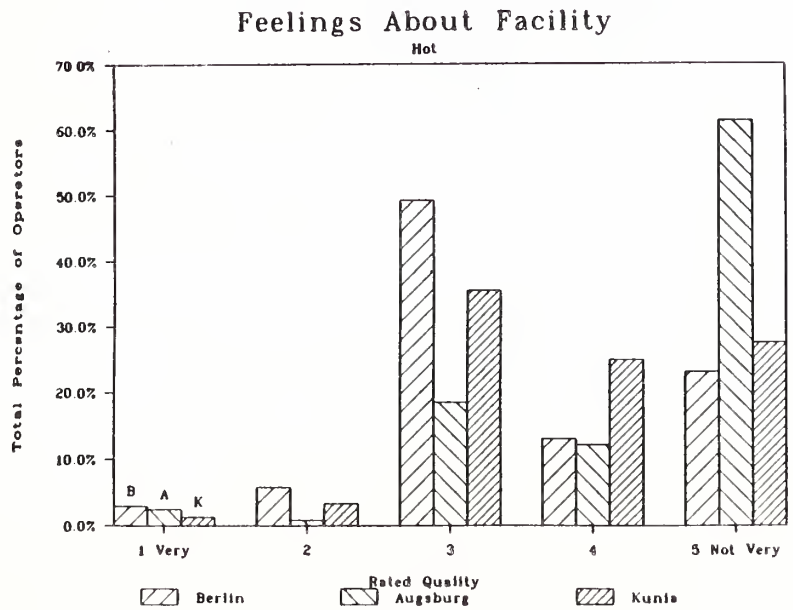


Figure 12. Percentage of People Indicating that their Workstation is Bothersome Because it is Hot





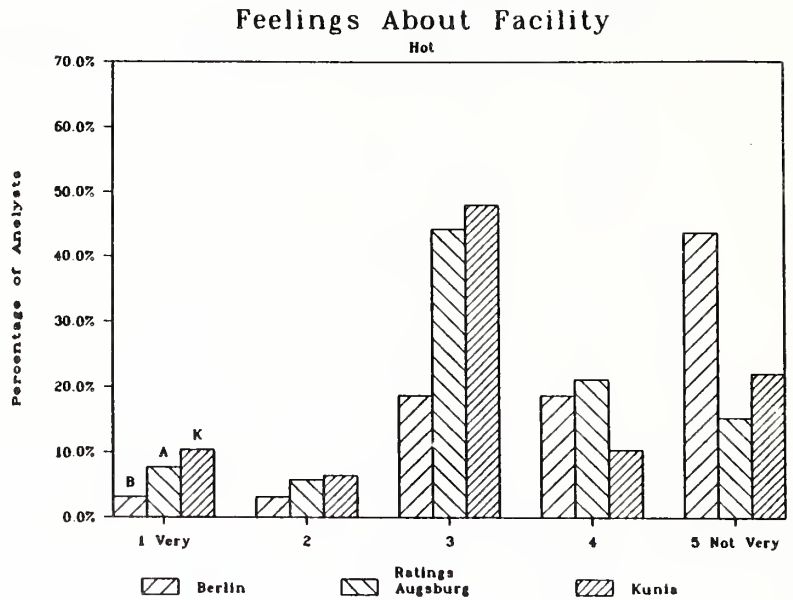
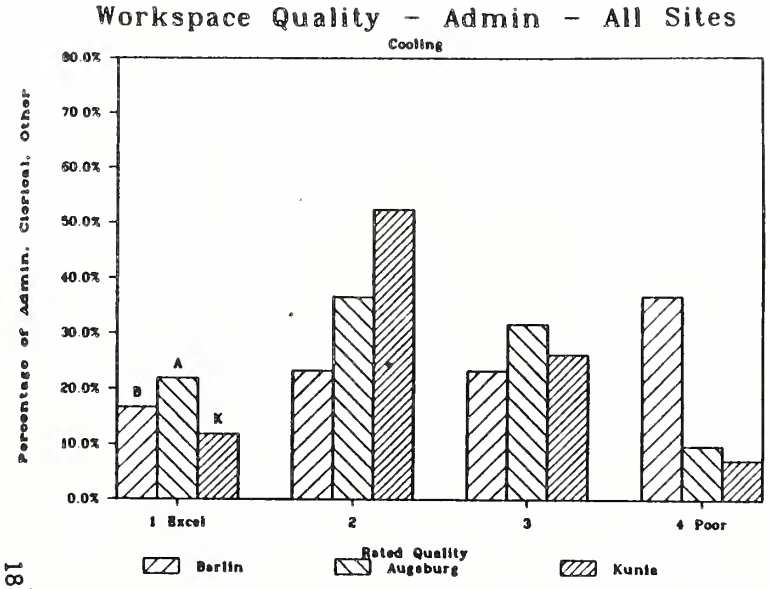
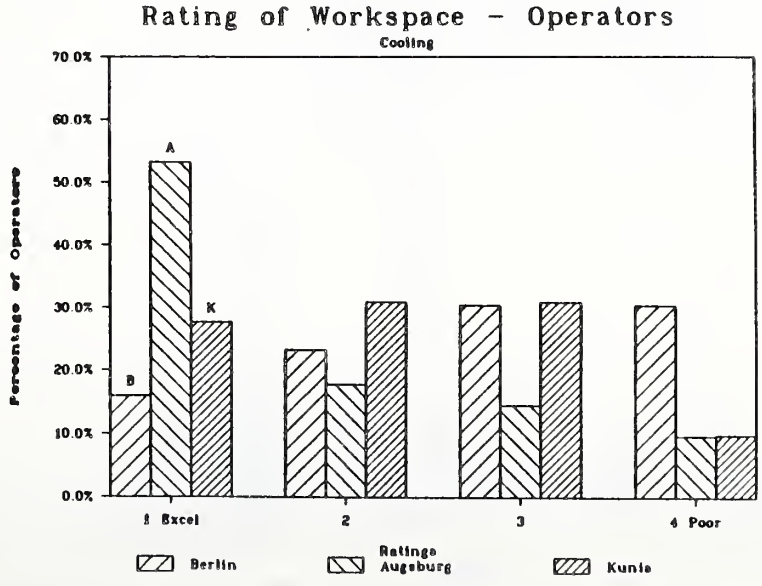


Figure 13. Percentage of People Indicating that their Facility is Hot





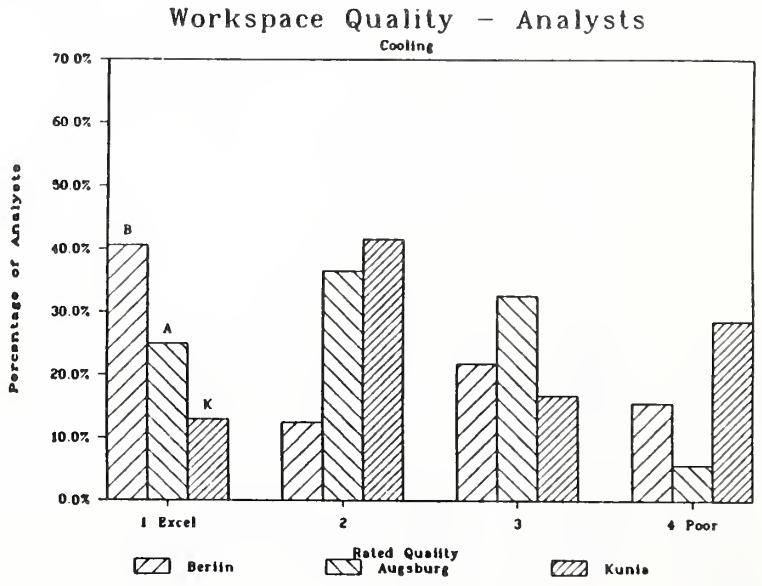


Figure 14. Percentage of People Rating the Quality of the Cooling in their Workstation

recorded by Rubin and Collins (1987) in December 1986 for Kunia were somewhat lower - between 66 °F and 71 °F, particularly on the operations floor. Individual temperatures at all sites were generally cooler in operations, often between 65 and 70°F because of equipment needs.

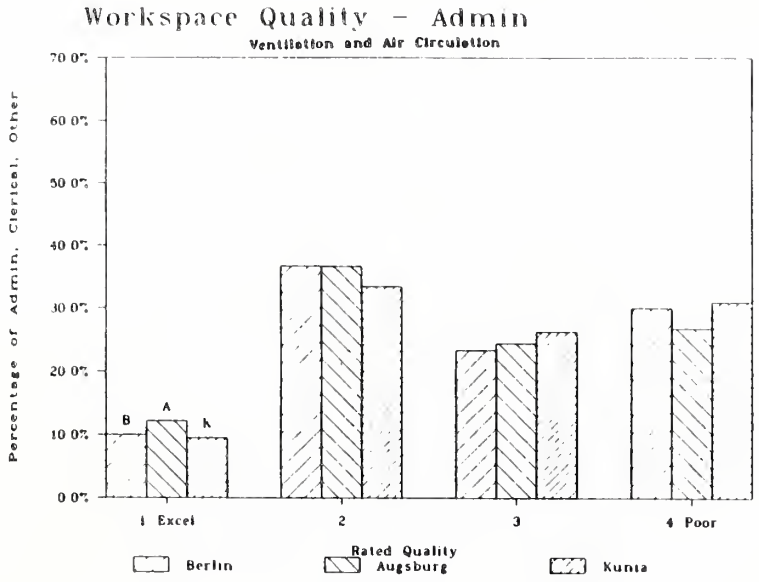
Responses to questions about ventilation (figures 15 - 17) do not show a particularly consistent pattern among job types or field stations. Thus figure 15 indicates that administrators and operators at all 3 sites were about evenly divided in their ratings of good, fair, and poor. Analysts in Berlin and Augsburg tended to rate the ventilation as good while those in Kunia saw it as poor. (In Berlin, ventilation around the latrines was particularly poor with offensive odors extremely common.)

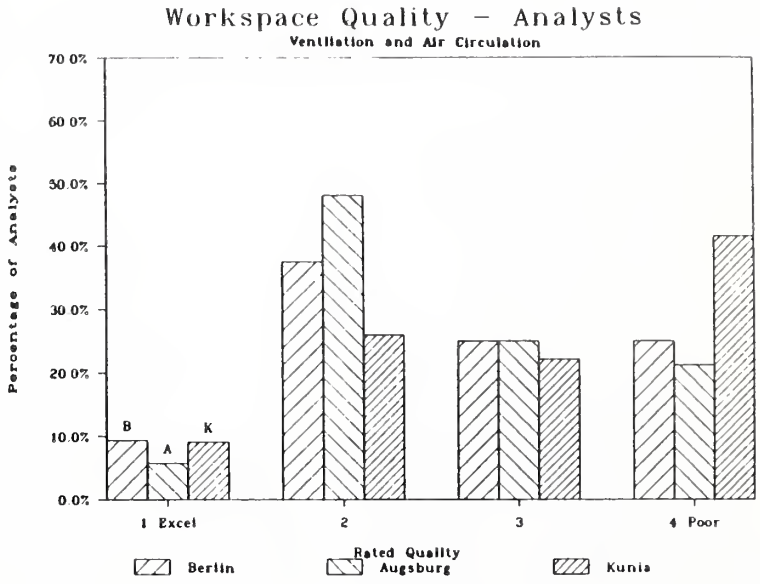
In general, Figure 16 indicates that respondents, particularly operators, did not find their work station to be "too stuffy", although about 35% of the analysts at Kunia indicated that stuffiness was "very bothersome". Too many drafts emerged as a problem for more than 40% of the operators in Augsburg, and about 35% of the analysts in Berlin. Yet 40% of administrators and analysts at Kunia were not bothered by drafts (figure 17). Figure 18 suggests that in Kunia, analysts found air quality poor while the administrators found it to be good. Administrators and operators at all three sites tended to find their air quality to be "good" or "fair" although more than 20% at Berlin found it to be poor. Thus, the analysts, who are often cramped for space, complain most of stuffiness and poor air quality in their offices.

3.3 Response to Lighting Conditions

3.3.1 Lighting Quality

Figure 19 to 31 present data on lighting conditions at the three sites. The first four figures (19 to 22) present overall attitudes about general lighting quality in specific locations. Figure 19 indicates that lighting quality in the dining room was judged to be "pretty good" or "excellent", with very few negative ratings. Similarly, the break areas were judged to be "pretty good", particularly by operators, for all 3 sites. Analysts and operators were more positive about lighting quality in restrooms, while administrators, particularly those in Berlin were somewhat more negative. Figure 22 suggests that administrators at Kunia were quite positive about the lighting quality in their workspace with 80% considering it good or excellent. Administrators at the other 2 sites were also reasonably positive, although about 35% at Augsburg considered their workspace lighting "not very good" or "poor". About 50% of the analysts at Berlin rated their lighting as "not very good" or "poor", while analysts at Augsburg and Kunia were more positive. Finally, operators in Berlin and Kunia rated their workspace lighting more favorably than those in Augsburg. Of the four spaces shown in figure 19 to 22, the workspace received the fewest "excellent" and the most "poor" ratings for lighting quality.





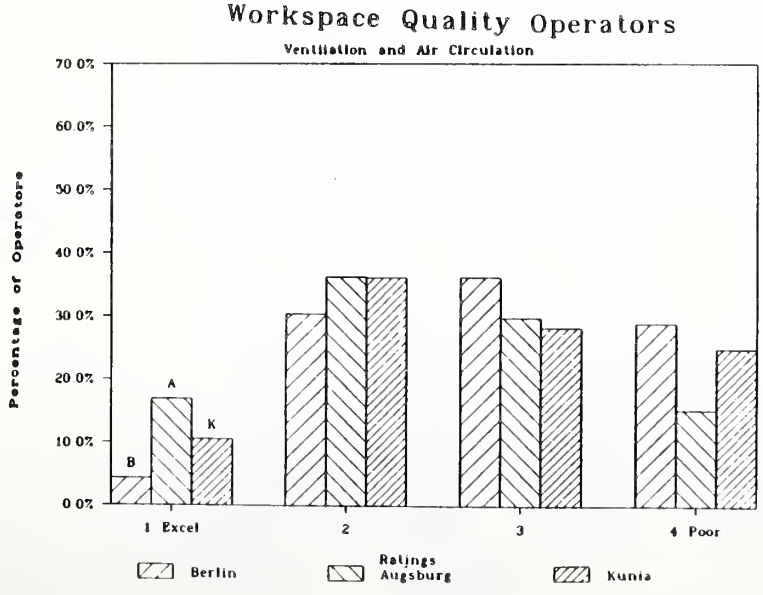
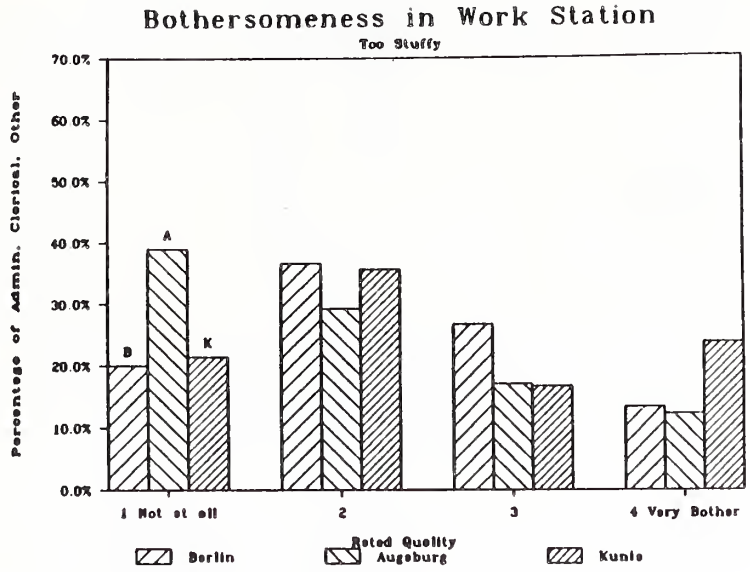
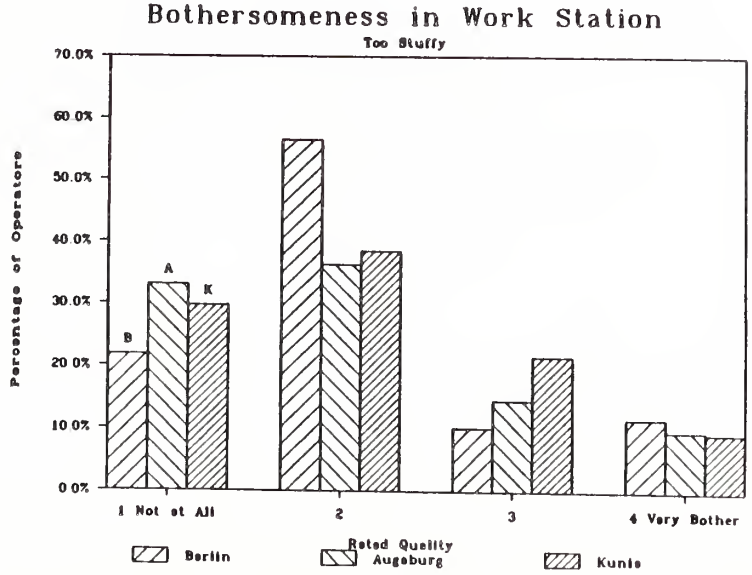


Figure 15. Percentage of People Rating the Quality of Ventilation and Air Circulation in their Workspace





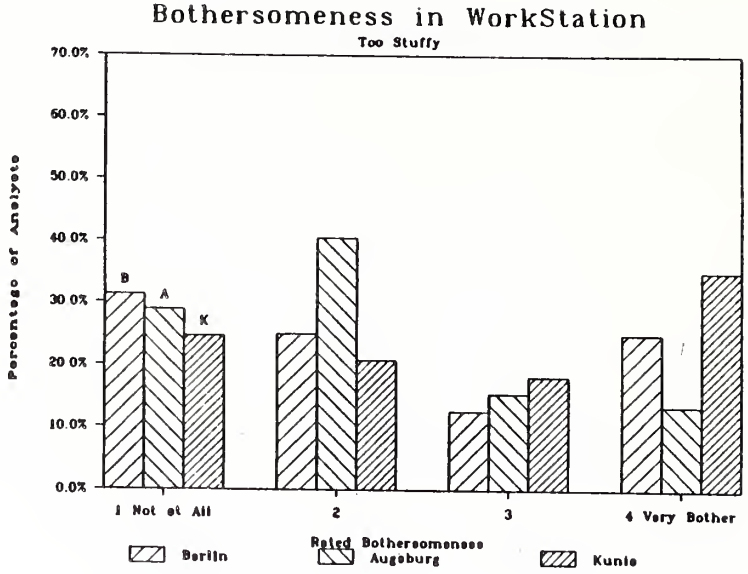
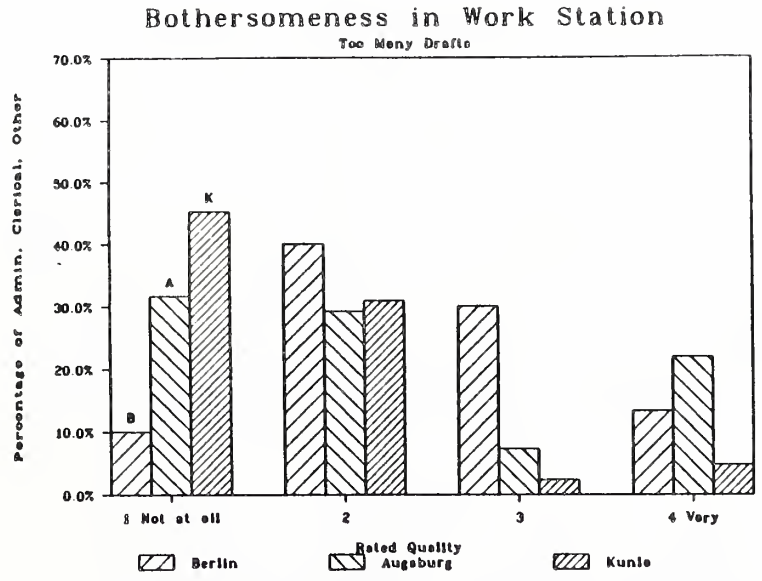
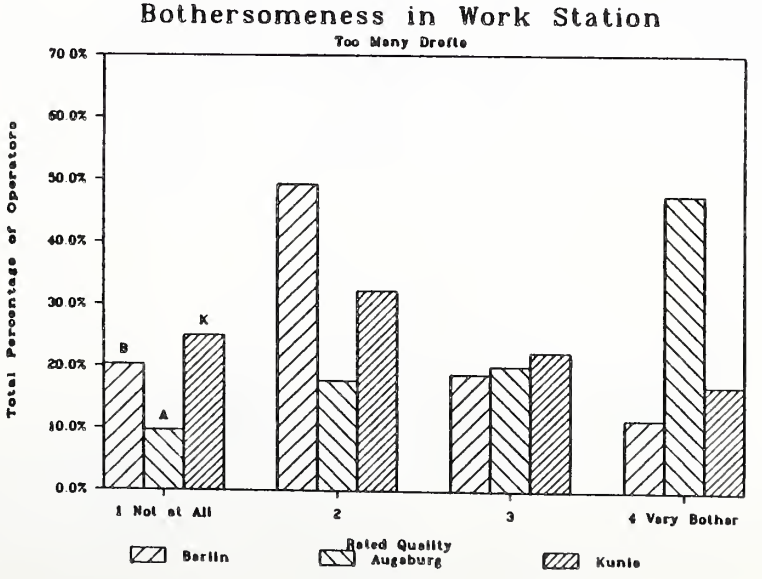


Figure 16. Percentage of People Indicating that their Workstation is too Stuffy





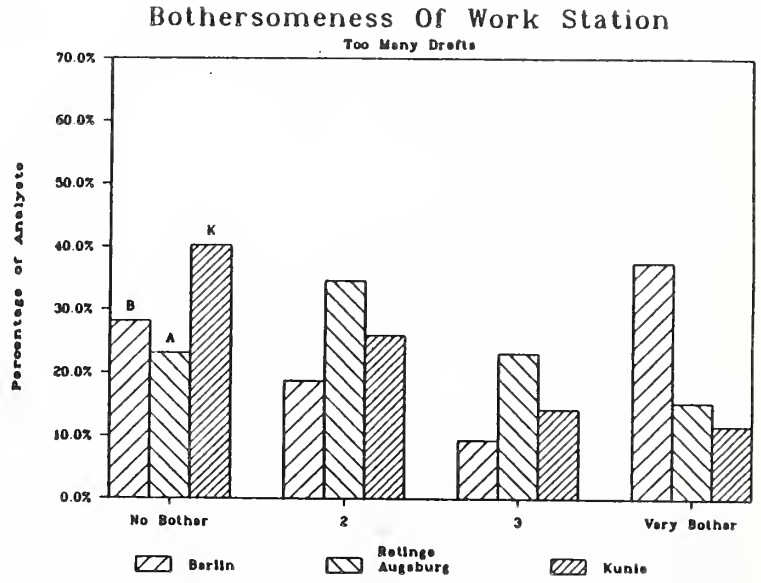
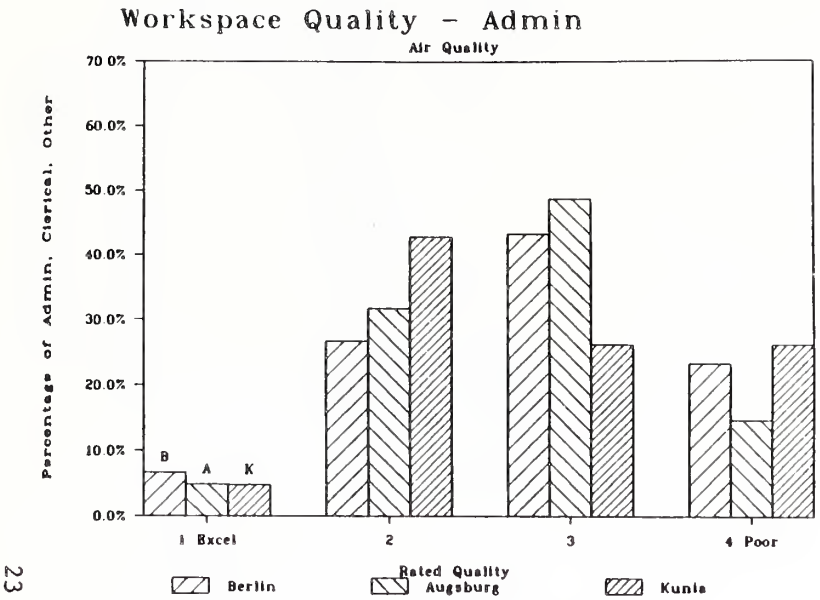
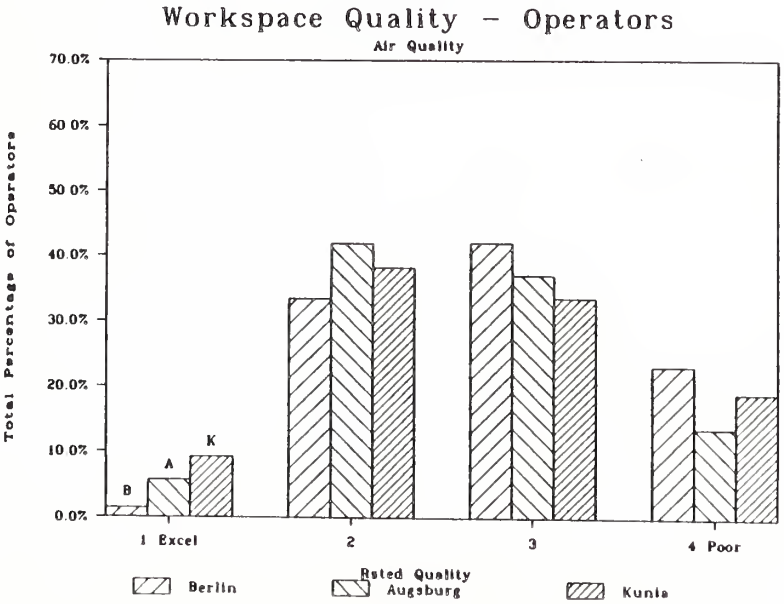


Figure 17. Percentage of People Indicating that there are too many Drafts at their Workstation





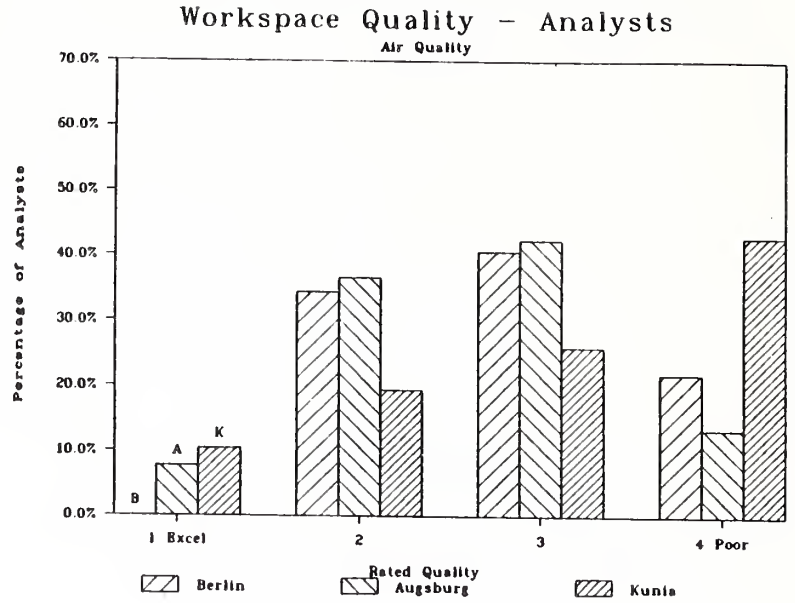
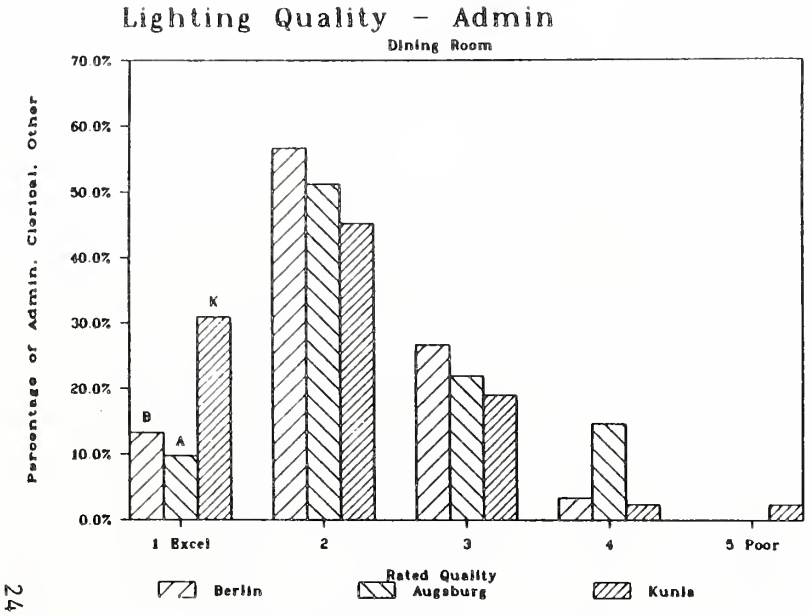
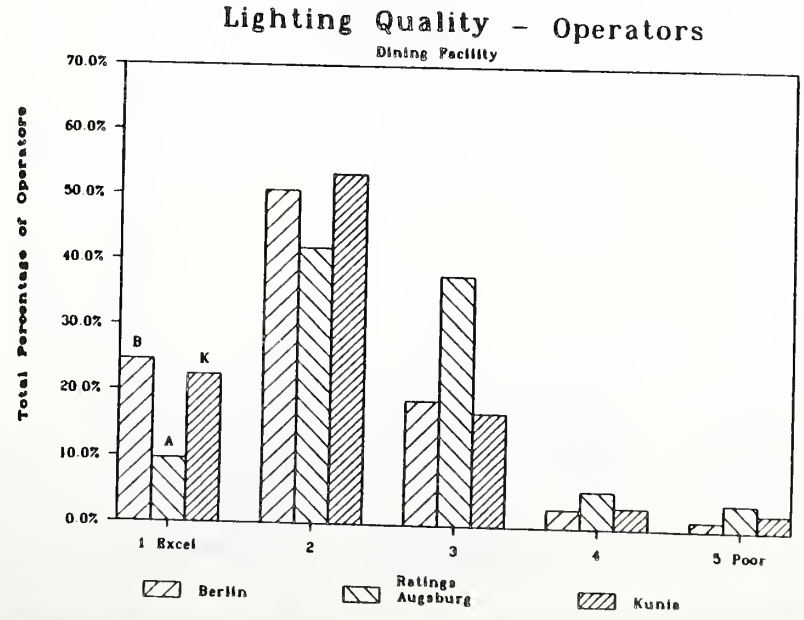


Figure 18. Percentage of People Rating the Quality of the Air at their Workstation





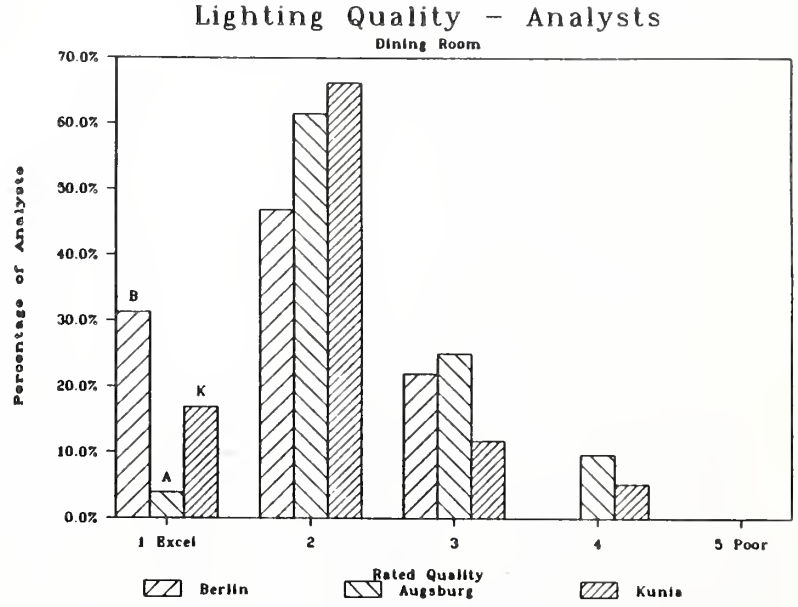
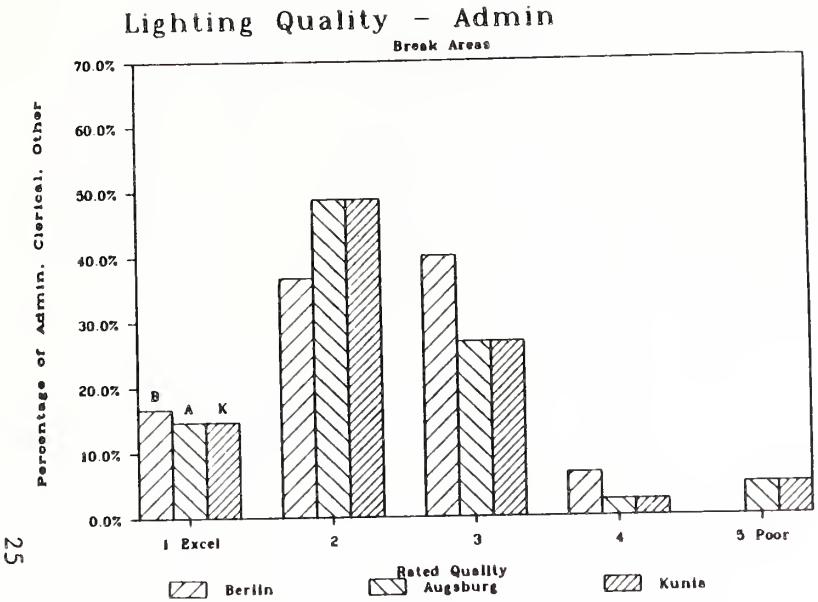
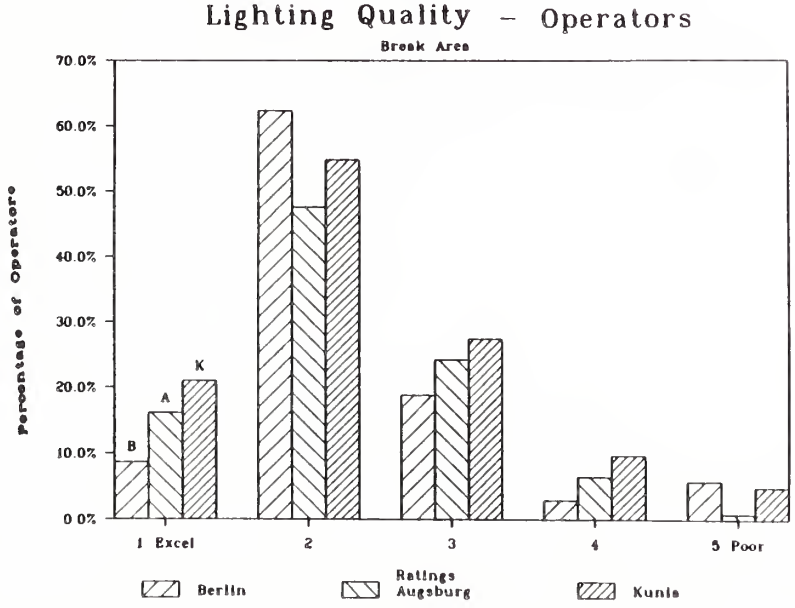


Figure 19. Percentage of People Rating the Quality of the Lighting in the Dining Room at each Field Station





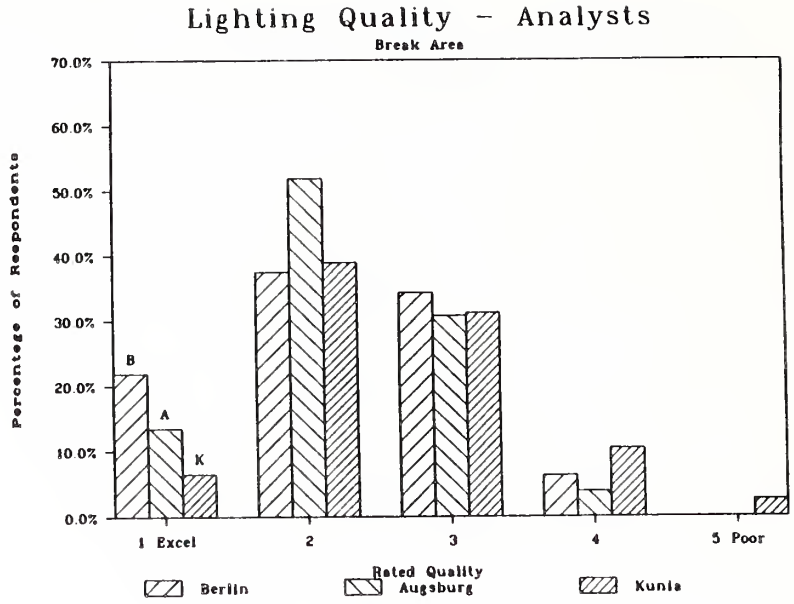
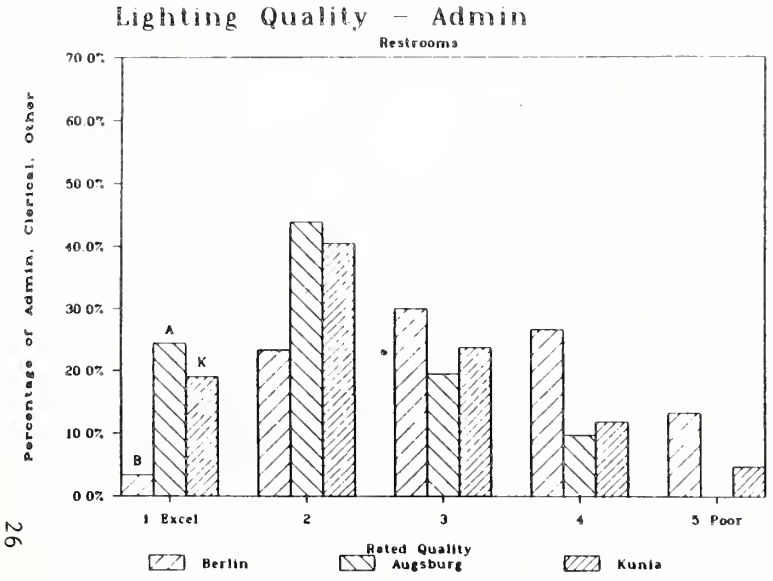
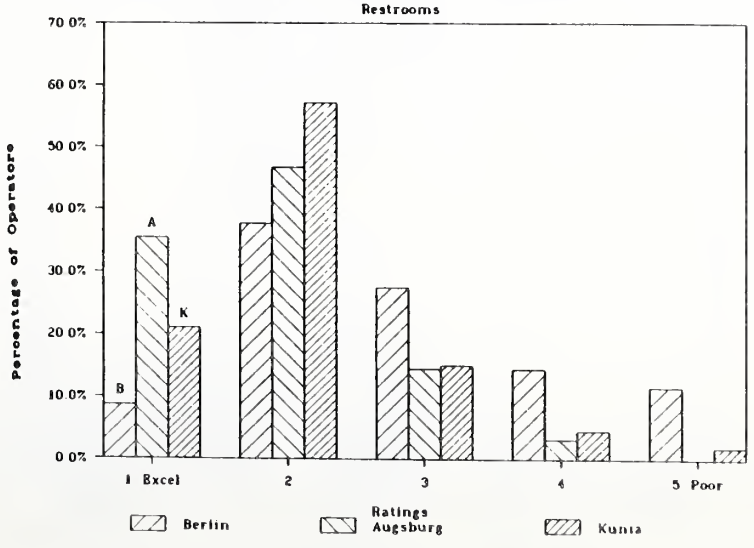


Figure 20. Percentage of People Rating the Quality of the Lighting in the Break Area for the Field Stations





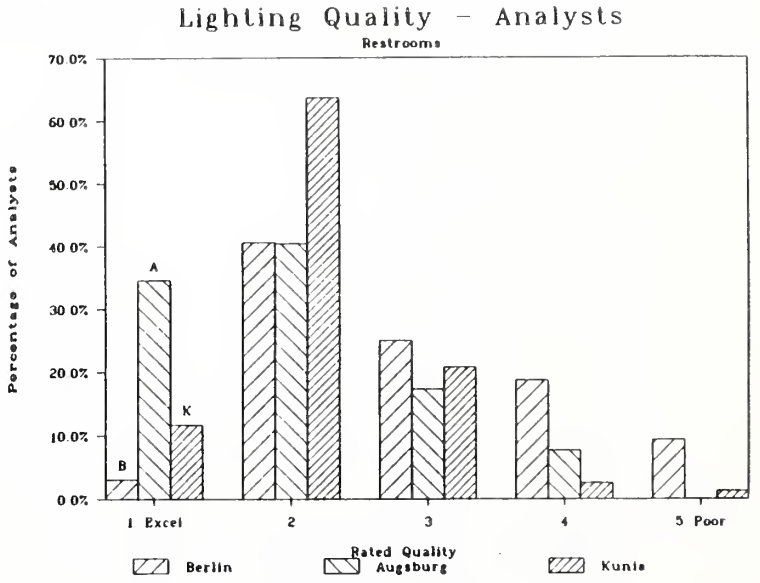
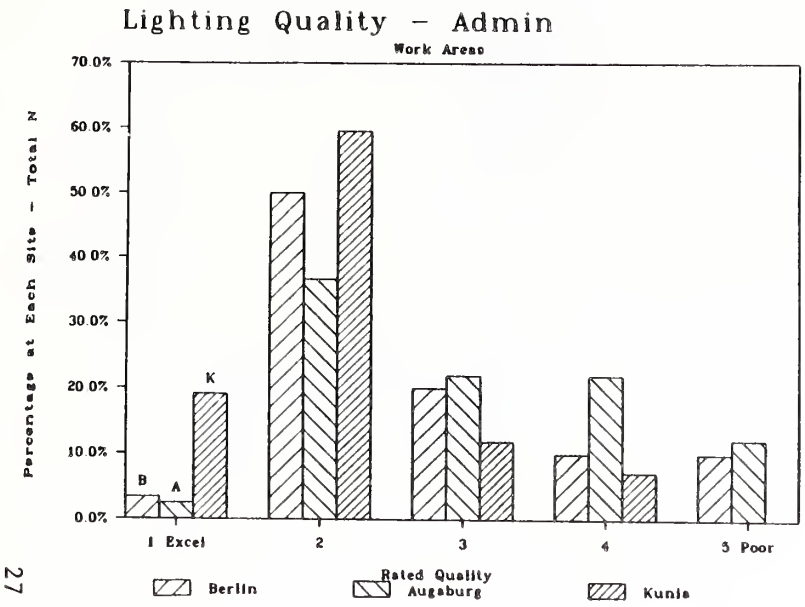
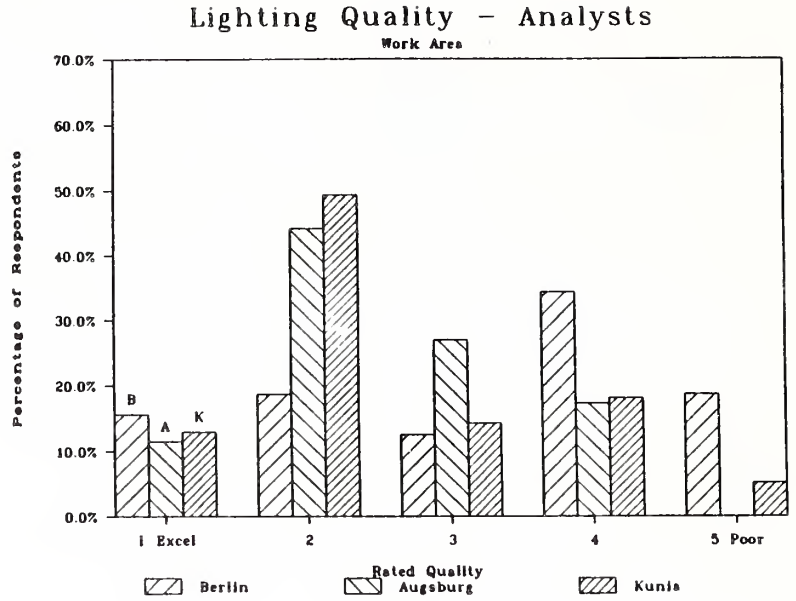


Figure 21. Percentage of People Rating the Quality of their Lighting in the Restrooms at the Field Stations





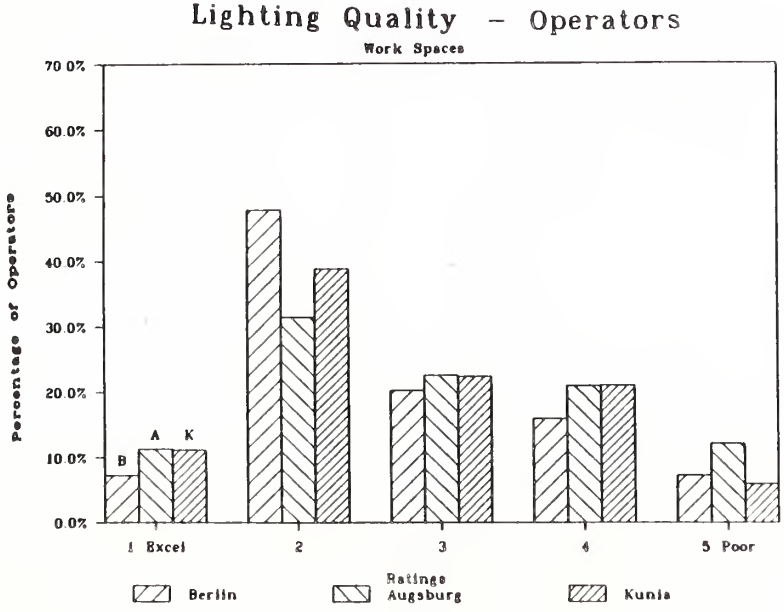
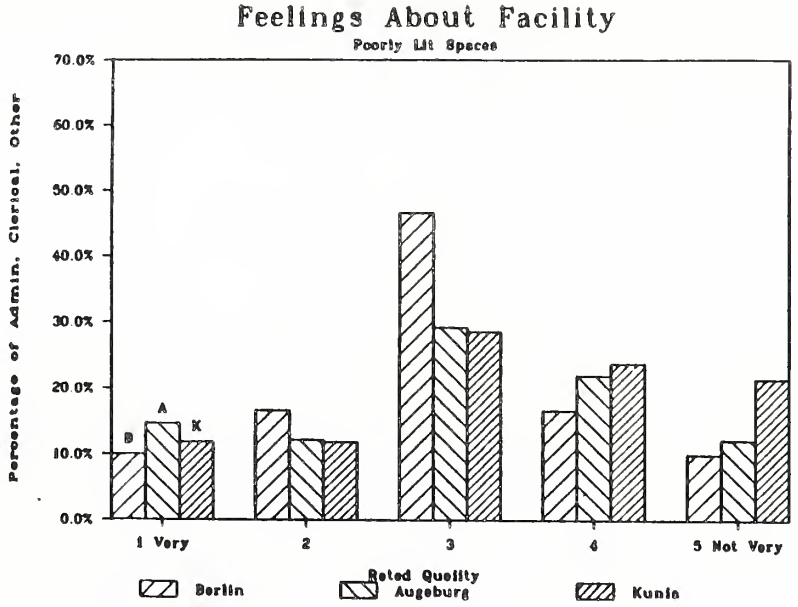
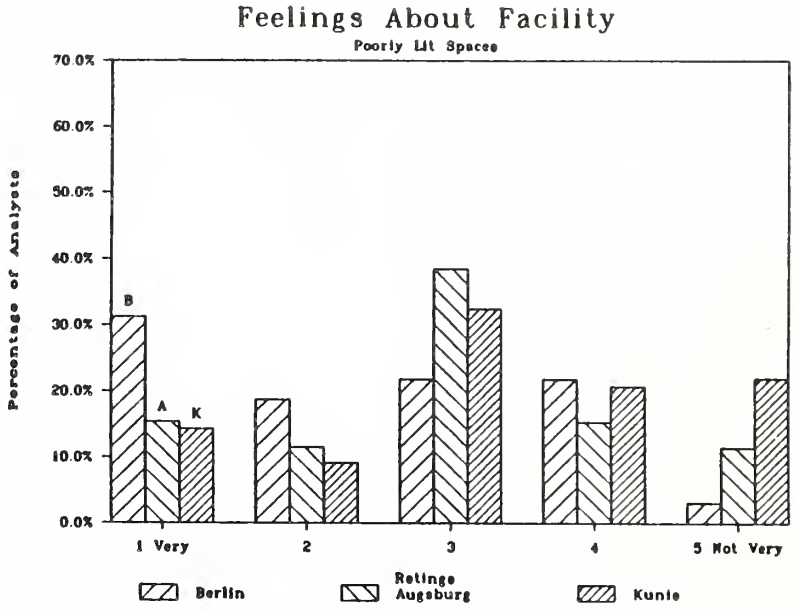


Figure 22. Percentage of People Rating the Quality of Lighting in their Work Areas at each Field Station





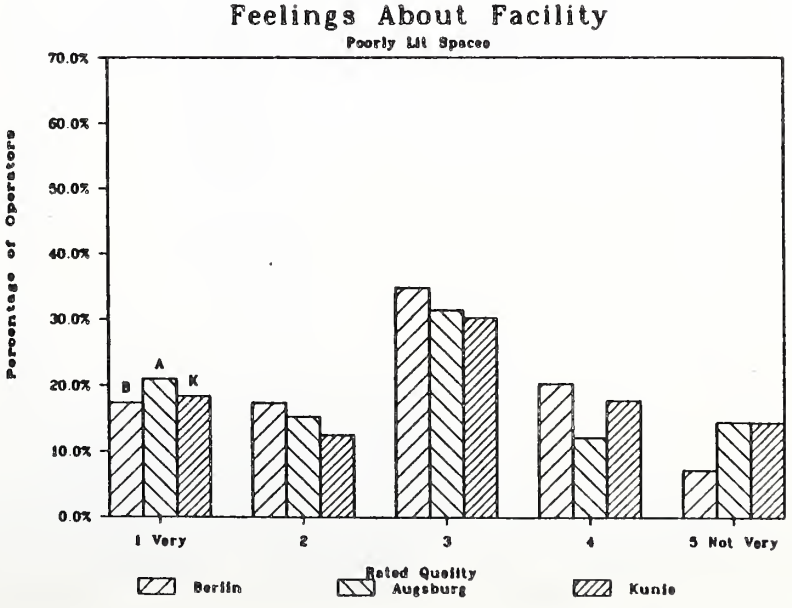
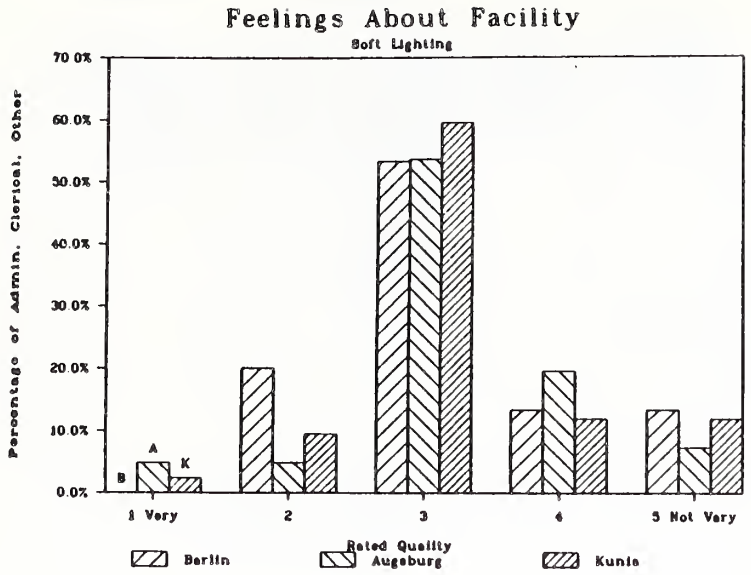
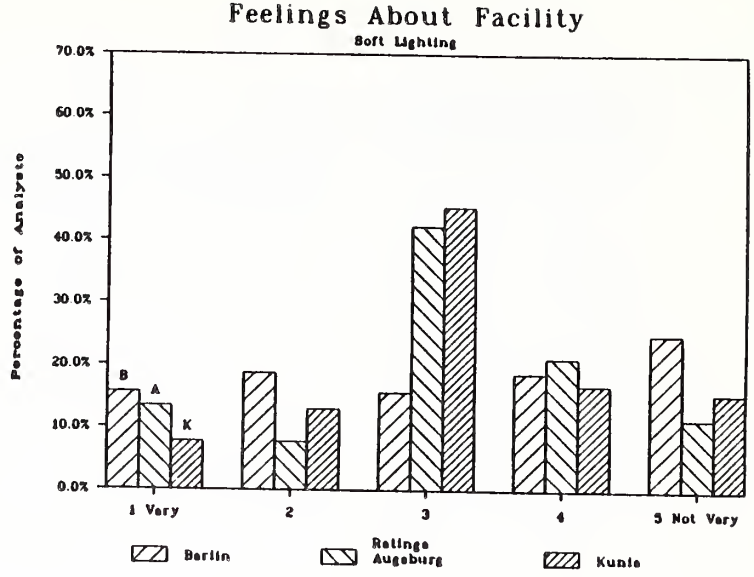


Figure 23. Percentage of People Indicating that their Facility Contains Poorly Lit Spaces





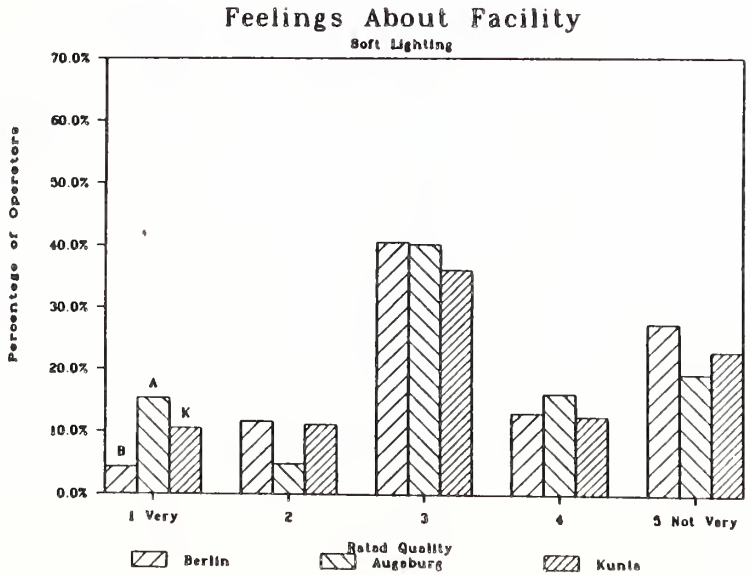
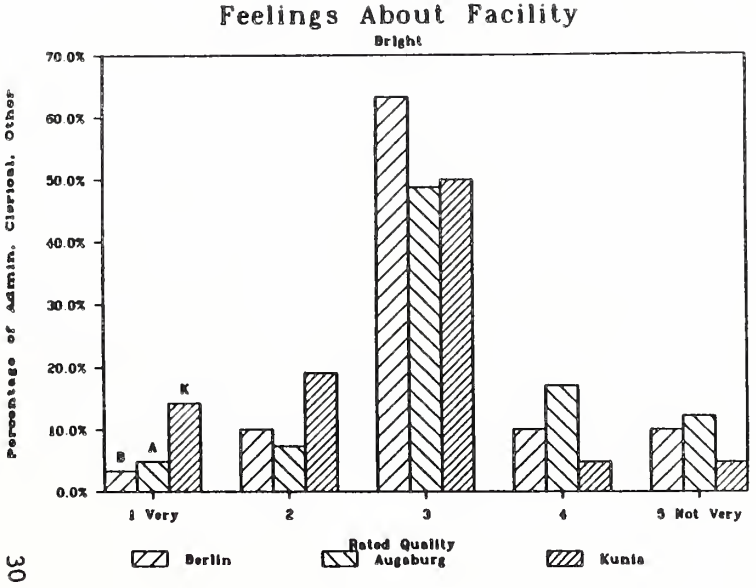
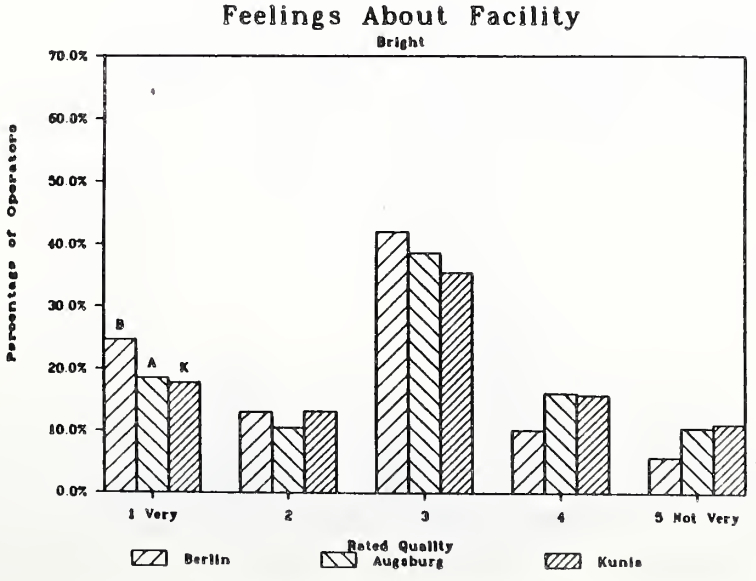


Figure 24. Percentage of People Indicating that their Facility has Soft Lighting





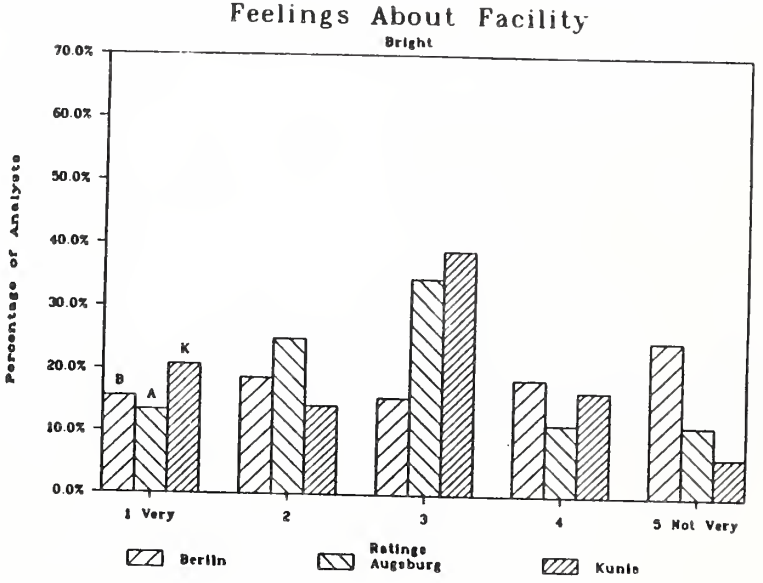


Figure 25. Percentage of People Indicating that their Facility has Bright Lighting

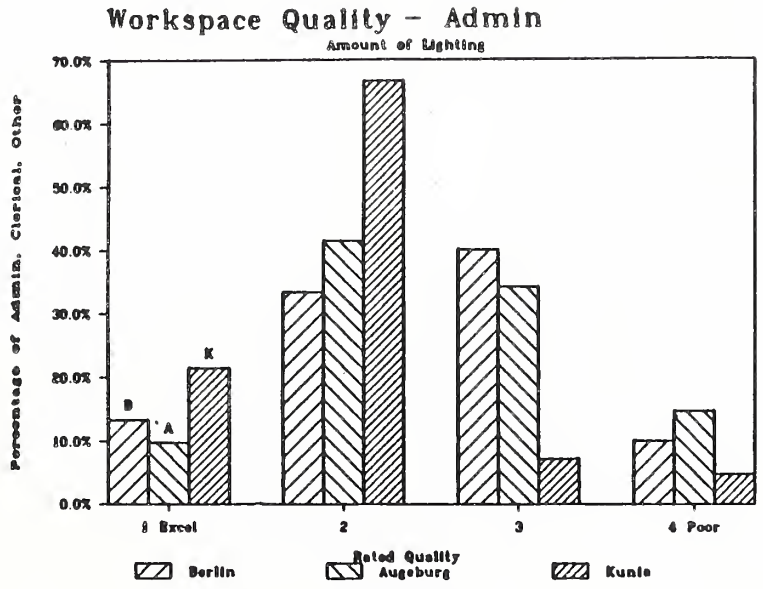
A series of questions (figures 23 to 25) dealt with general feelings about the lighting quality in the facility. Figure 23 does not reveal any clear attitude about the overall lighting quality with respondents evenly divided among the 5 categories, except for the Berlin analysts. About 50% of the latter consider their space to be poorly lit. In general, most respondents considered their facilities to be neither "softly" nor "harshly" lit (figure 24) and neither "bright" nor "dim" (figure 25), with 40% or more responding neutrally to these questions.

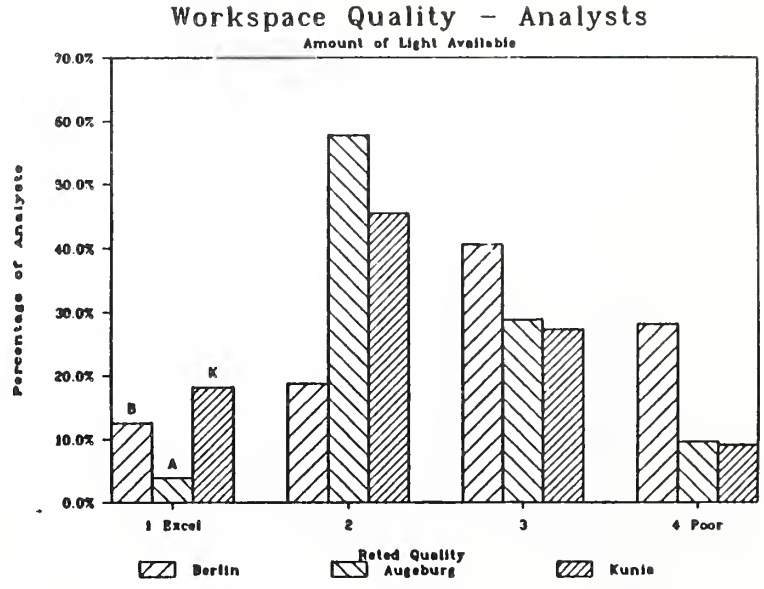
3.3.2 Lighting Quantity

The pattern of answers is more definitive for questions directly related to workstation lighting needs. For example, figure 26 presents responses to a question about the amount of workstation light. In general, about 40 - 50% of the respondents believed their lighting was "good" or "excellent". In fact almost 90% of administrators at Kunia were very positive about the amount of light. Those at Berlin and Augsburg considered the amount to be "good" or "fair". Operators and analysts at all sites also tended to see the amount of light as "good". (At all three field stations, operators had deliberately reduced lighting levels to reduce glare on their VDT screens by removing lamps, adding paper diffusers, or switching off sources.)

Analysis of the data for lighting levels, presented in section 5, indicates that the mean illuminance was always highest in the administrative areas and lowest in operational areas for all three sites, (as good practice would suggest). Overall lighting levels were lowest for Augsburg, however, with the mean illuminance for (310 lux) administrators without VDT's being 200 lux less than for the same type of space in Berlin and Kunia. Lighting levels were much lower for operators with means of 127 to 197 lux. The levels for analysts with VDT's were also low with a mean illuminance of 188 lux at Berlin, 144 lux at Augsburg, and 276 lux at Kunia. While contrasts on the VDT screens were higher at the lower light levels, contrasts on paper tasks in the same space were quite low. For the analysts who do both paper and VDT tasks, the light levels are low enough to make it difficult to work with paper copy, particularly computer printouts.

Figure 27 indicates that at least 40% of analysts in Berlin felt their light was too dim - all other respondents were "neutral" on this question. Figure 28 provides further evidence of the dissatisfaction of the Berlin analysts with their lighting. About 65% were "less than satisfied" with their lighting. Most other respondents, however, were reasonably satisfied, with 78% of Kunia administrators considering their lighting to be "good" or "excellent". Operators appeared to be more satisfied than dissatisfied, although their responses were fairly evenly distributed across the categories. Figure 29 indicates that all respondents did not believe that lighting seriously hinders their job performance, although at least 30% at each site thought that there was some negative impact.





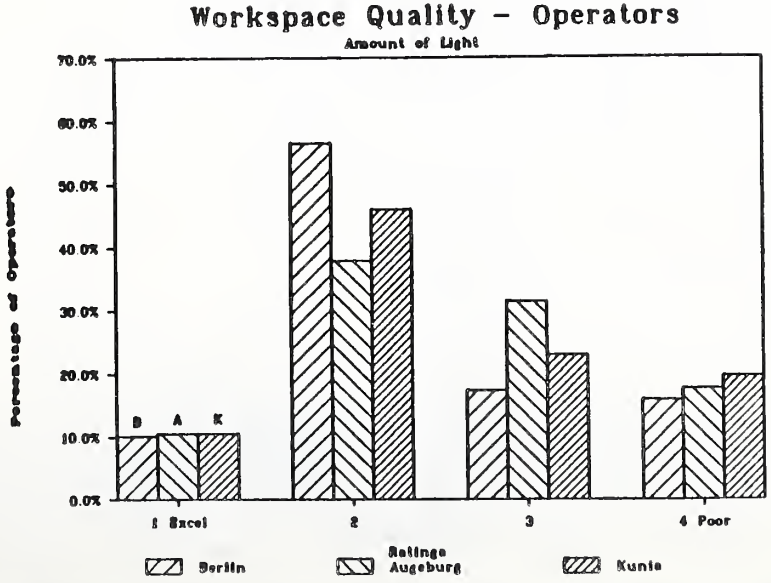
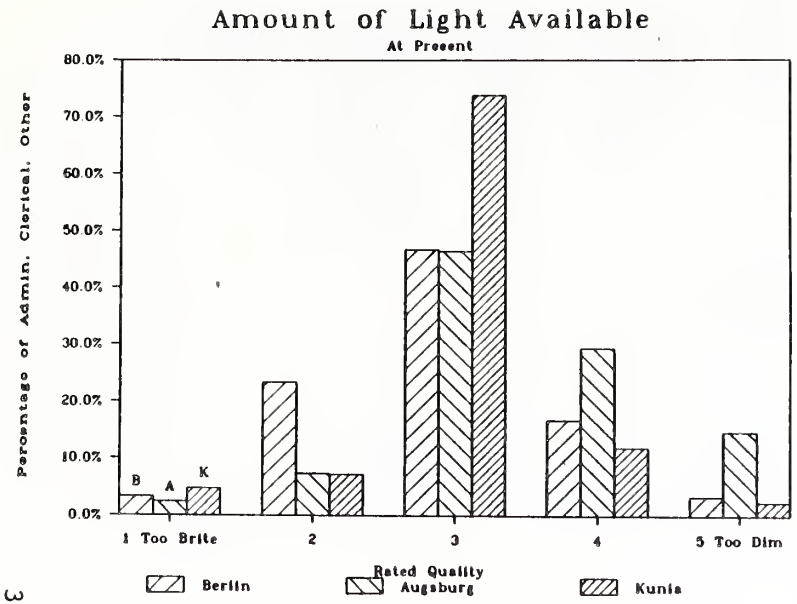
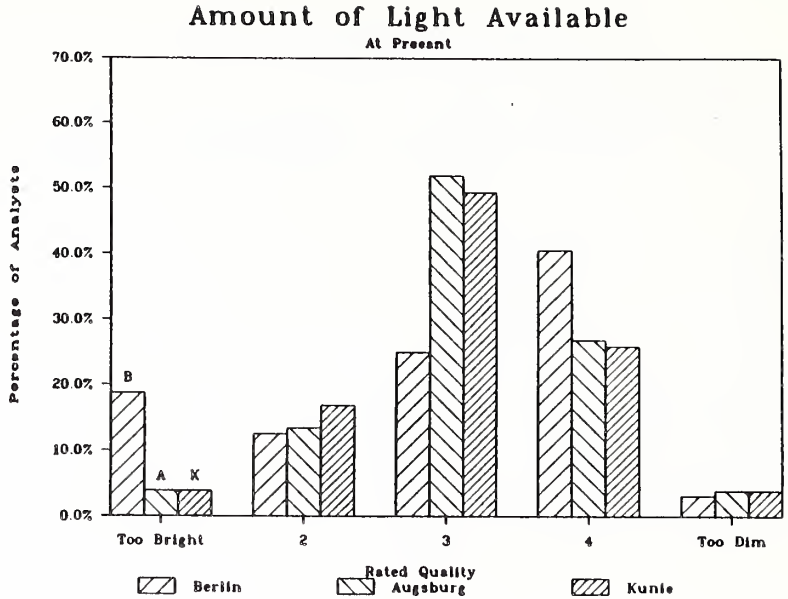


Figure 26. Percentage of People Rating the Amount of Lighting in their Workspace.





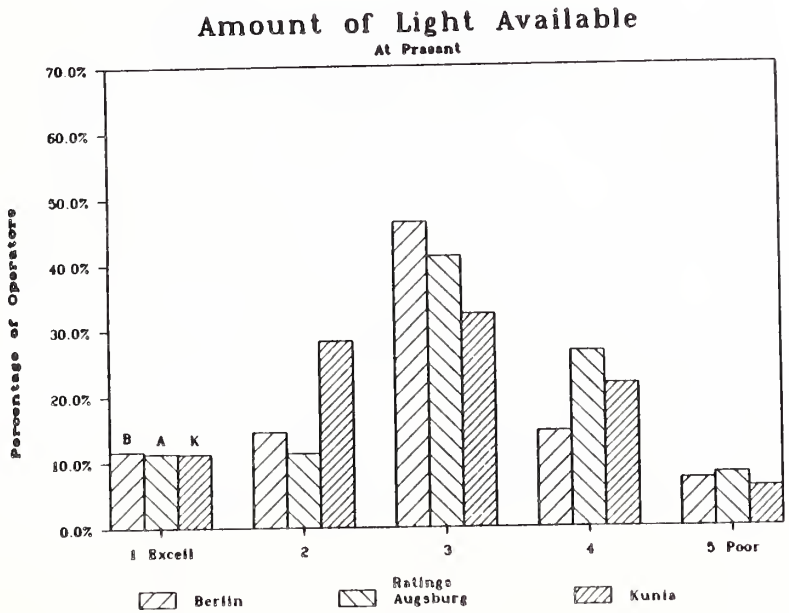
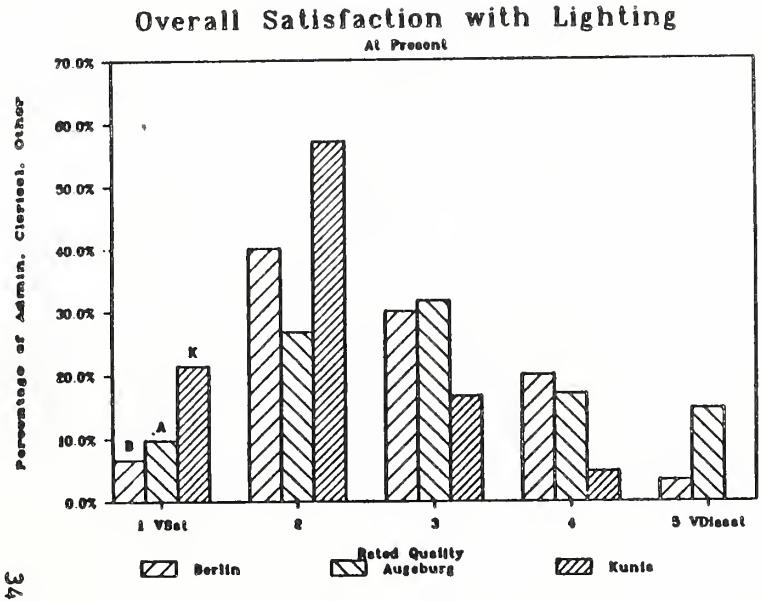
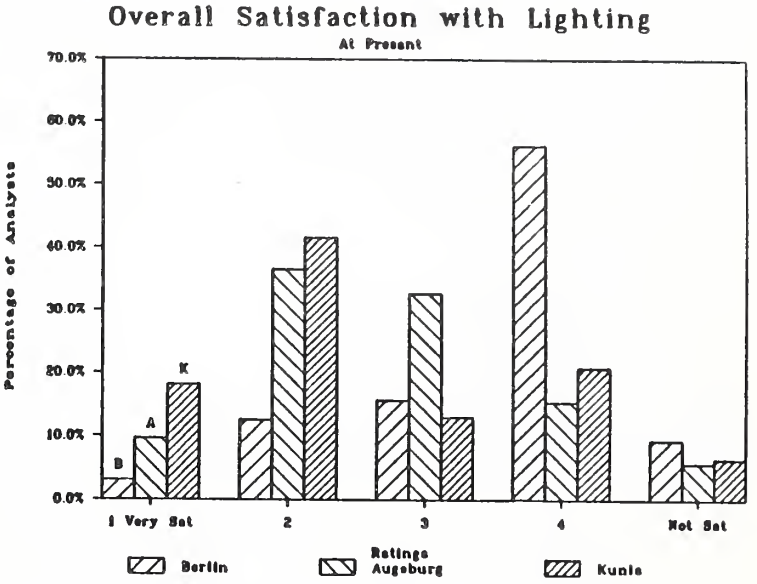


Figure 27. Percentage of People Rating the Brightness/Dimmer of the Light at Present





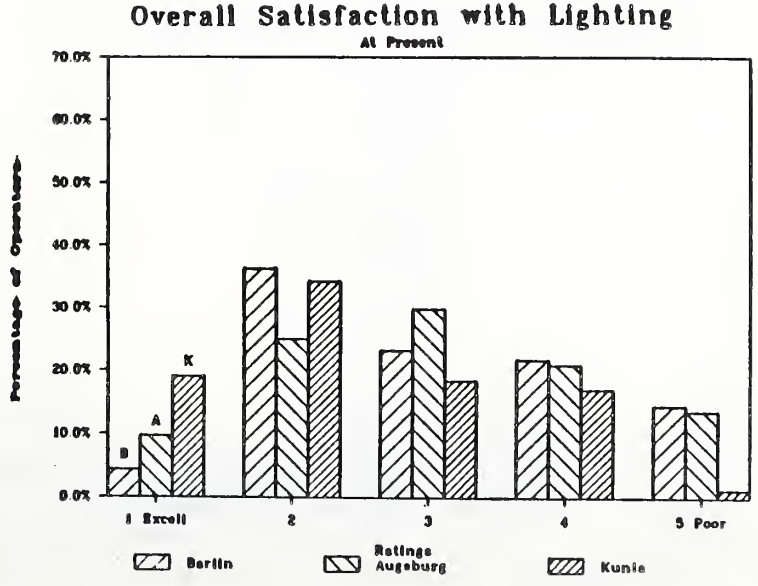
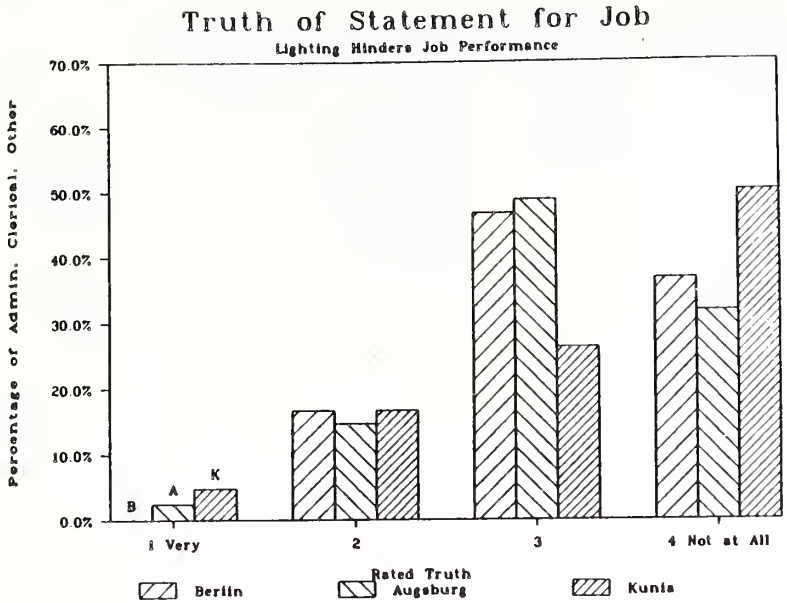
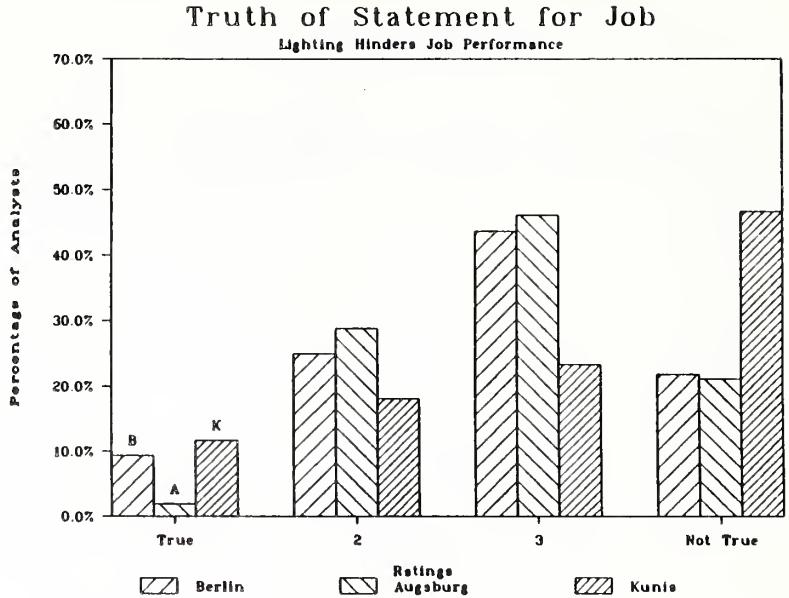


Figure 28. Percentage of People Rating their Overall Satisfaction with their Lighting





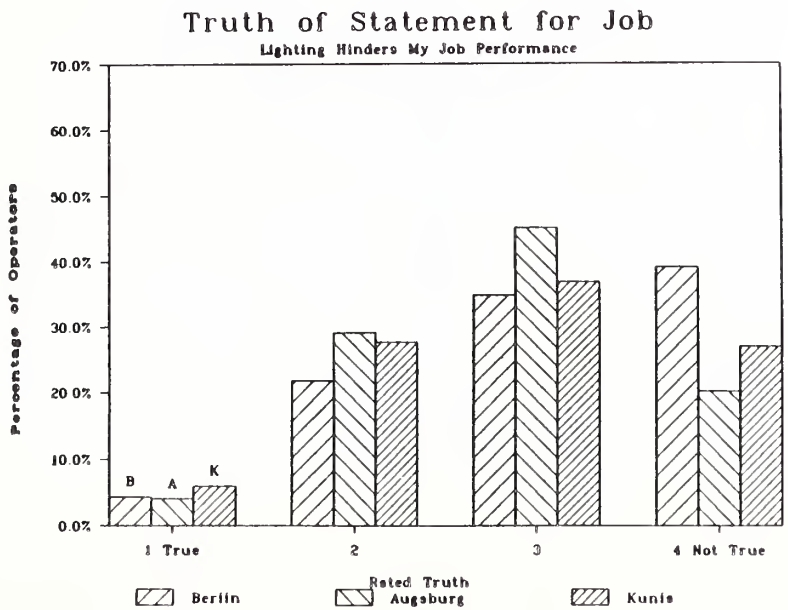
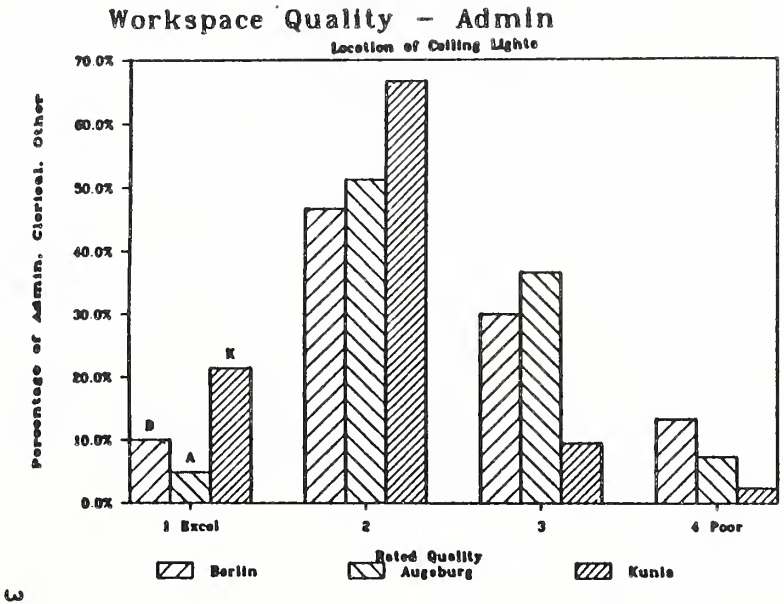
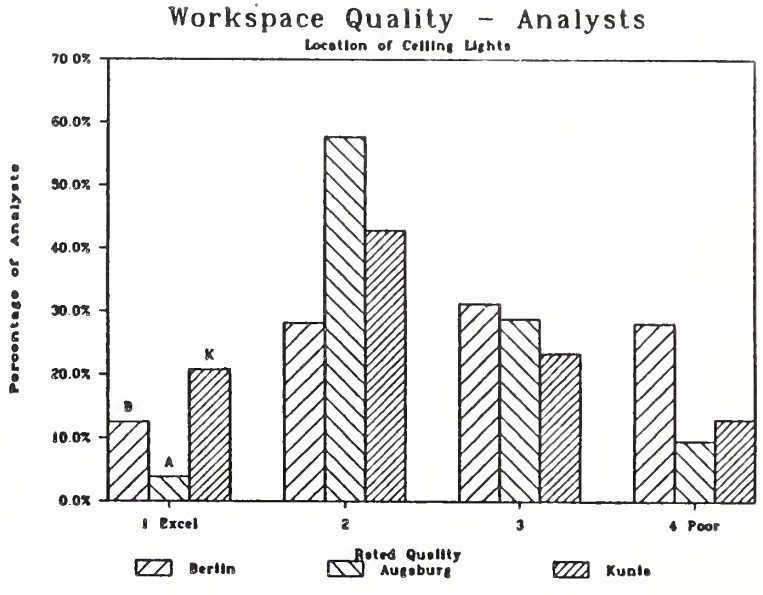


Figure 29. Percentage of People Indicating the Truth of the Statement that Lighting Hinders their Job Performance





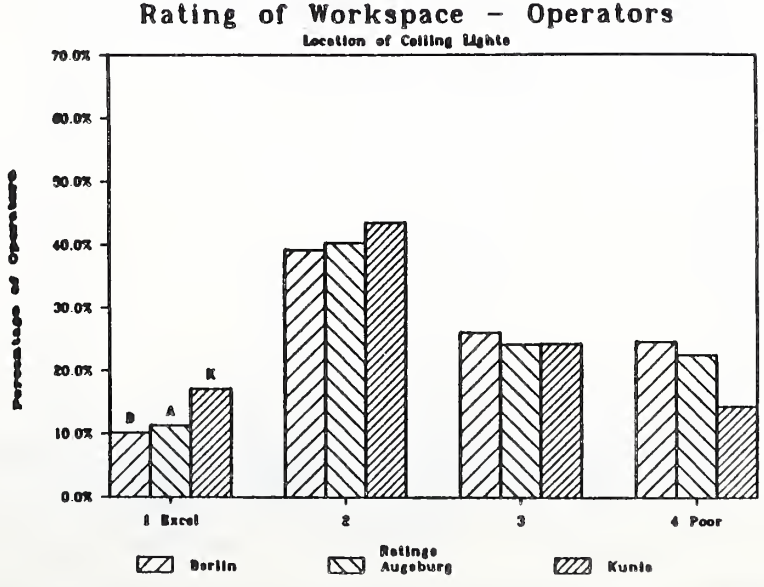
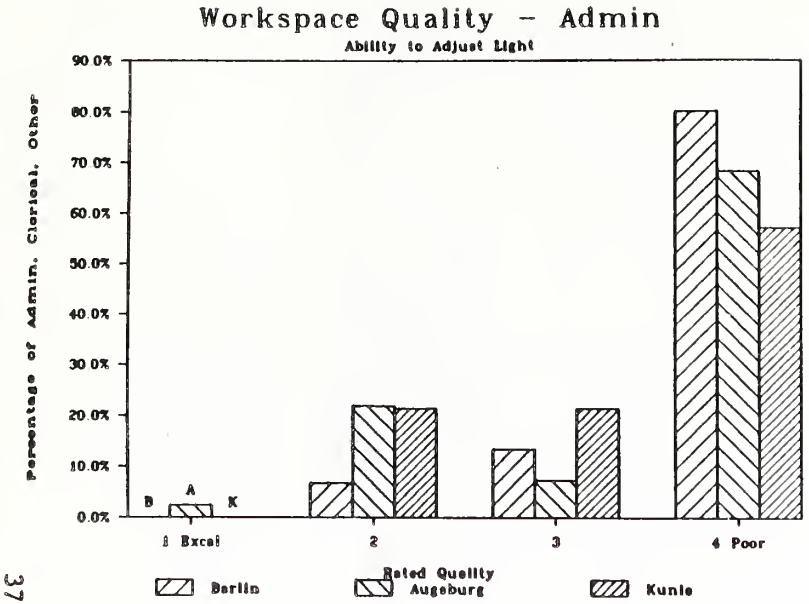
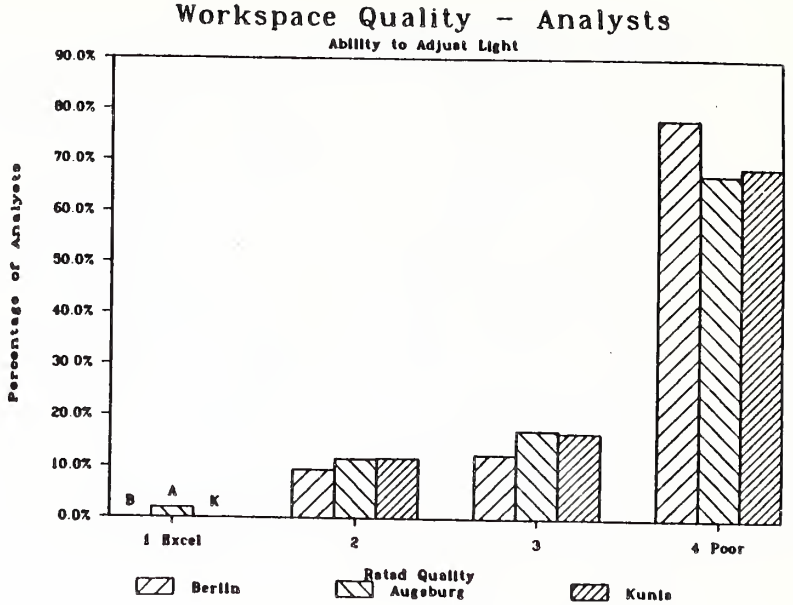


Figure 30. Percentage of People Rating the Effectiveness of the Location of Ceiling Lights





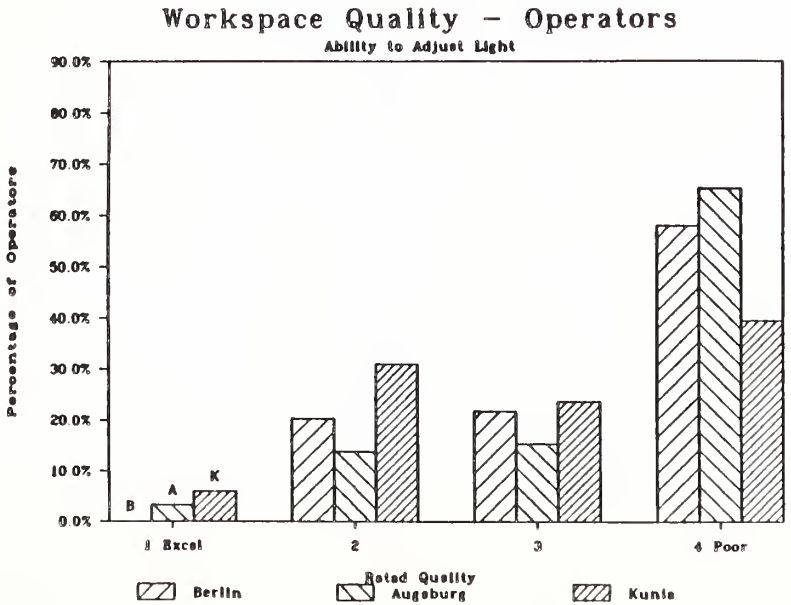


Figure 31. Percentage of People Rating their Ability to Adjust Light for their Tasks

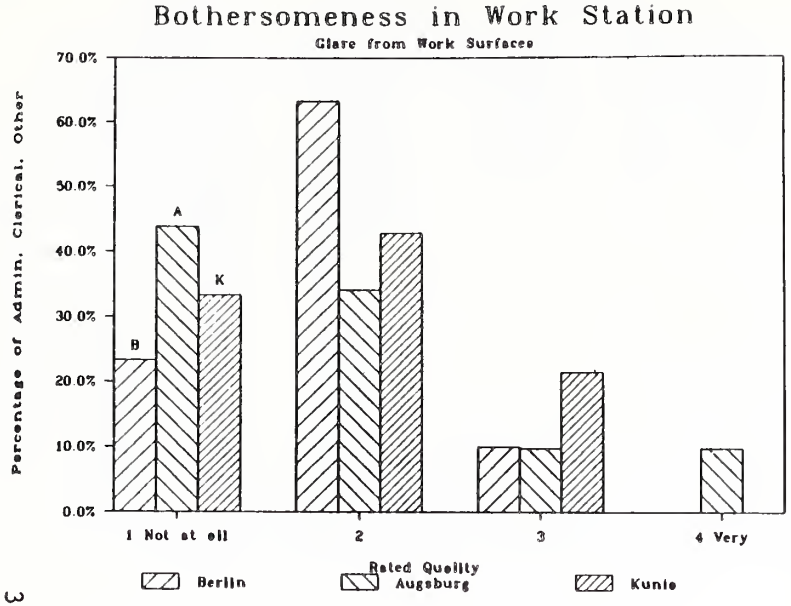
Figure 30 suggests that light location was good to excellent for administrators in Kunia, but was only good to fair for administrators at the other 2 sites. While 40% of the analysts believed that the light location was good, another 40% believed that it was fair to poor - a pattern which is even more apparent for operators. Figure 31 presents data on a major cause for the dissatisfaction with lighting - namely, the ability to adjust light for the task. Respondents at all sites rated their control over adjusting light as "very poor", with 70% of the analysts being particularly negative.

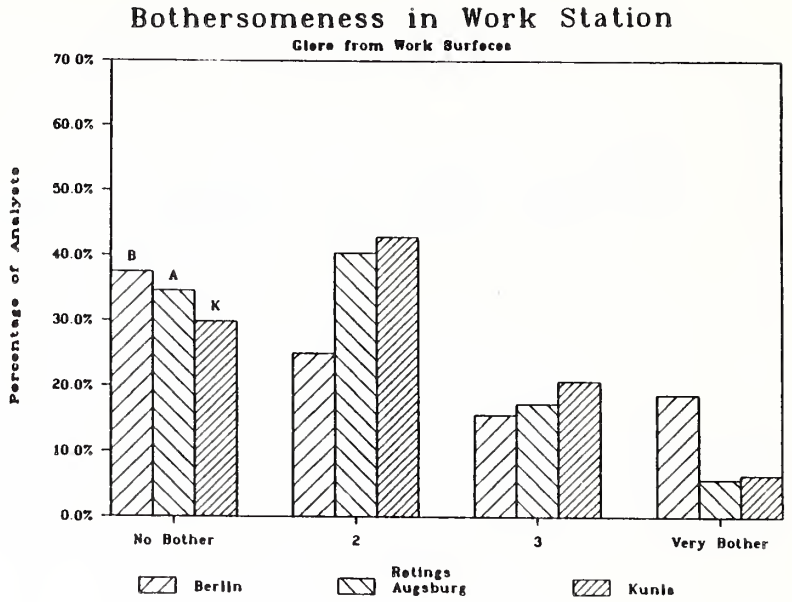
3.3.3 Task and Work Station Issues

The next series of figures (32 to 38) deal with potentially bothersome aspects of the lighting for the work station and task. Figure 32 indicates that the majority of at all respondents did not consider glare reflected from their work surface to be bothersome. Figure 33 indicates that administrators at all sites did not consider glare from ceiling lights to be a problem. On the other hand, Berlin analysts were evenly divided between those who believed ceiling light glare was or was not bothersome. Similarly, about 50 to 60% of all operators believed glare was not a problem, but 40 to 50% believed it was. Figure 34 indicates that overly dim lights were not a particular problem. Figure 35 and 36 indicates that brightness and glare from overhead light caused a problems in reading print for some analysts, particularly those in Berlin. Figure 37 indicates that the dimness of the overhead light was less bothersome, although about 40% of the Berlin analysts rated dimness as being "somewhat" or "very" bothersome. Responses given in figure 38 for the quality of lighting for reading show a clear pattern only for administrators and analysts at Kunia - who rated it positively.

3.3.4 Response to VDT's and Lighting Conditions

The next series of figures present data on the effects of lighting on using VDT's. Figure 39 indicates that reading printed copy while using a VDT was not a problem for any group. Operators, who had the lowest measured lighting levels of the three groups, did not consider reading print to be a problem. They are, of course, not required to work with printed tasks as much as the other two groups. Figure 40 indicates that most groups were neutral or positive about the impact of lighting on their ability to use a VDT. Responses to the bothersomeness of glare from overhead lights on VDT's, shown in figure 41, show no clear pattern. Similarly in figure 42, only the operators consistently rated the overhead light brightness as "not bothersome". (This is not surprising since they had taken steps to reduce overhead light brightness to very low levels). Figures 43, 44, and 45 indicate that screen angle, distance, and brightness did not cause problems for any group. The pattern of responses for screen flicker, given in figure 46, are much less clear cut, with only the Augsburg administrators judging it as "not bothersome at all". All other responses were divided among the rating categories.





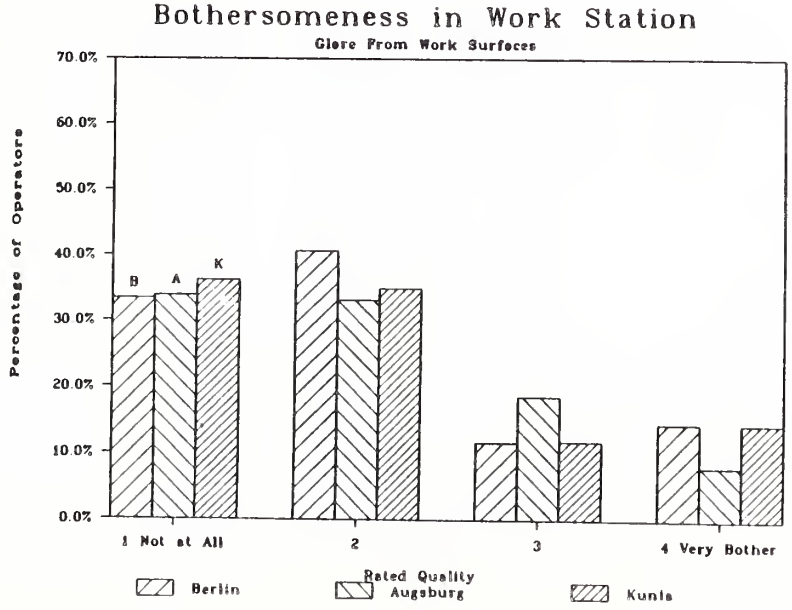
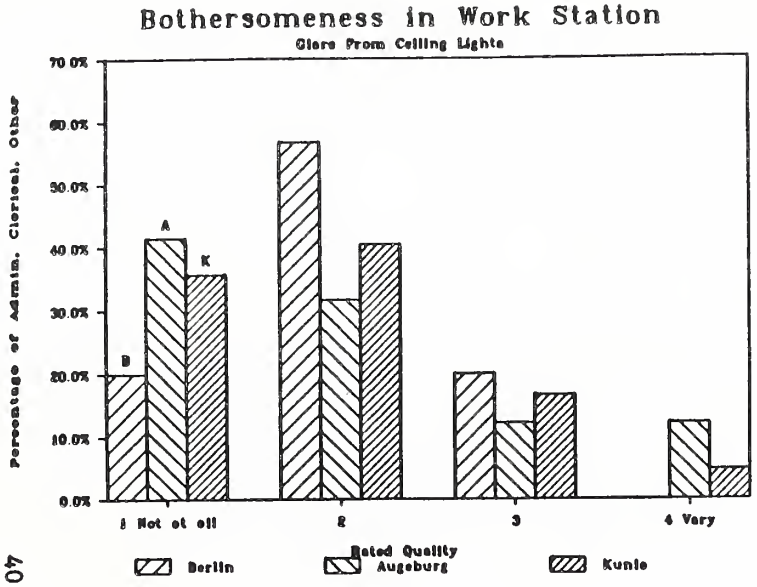
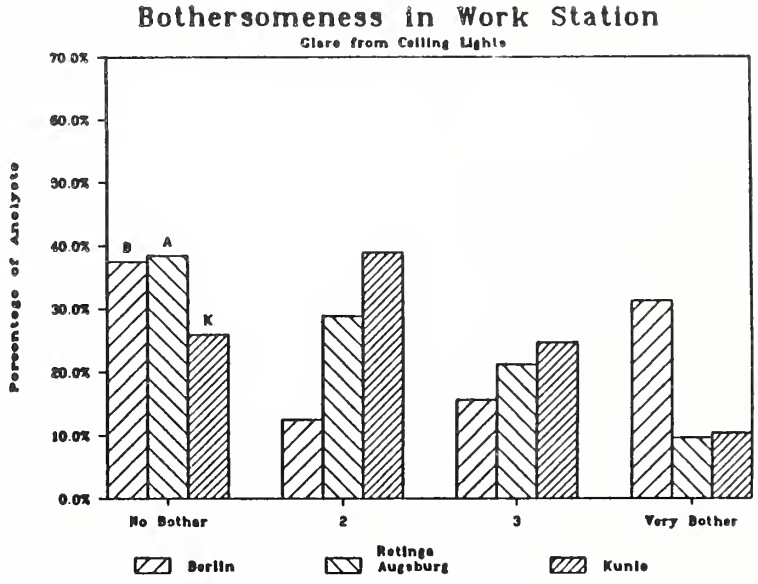


Figure 32. Percentage of People Rating the Bothersomeness of Glare from their Work Surface





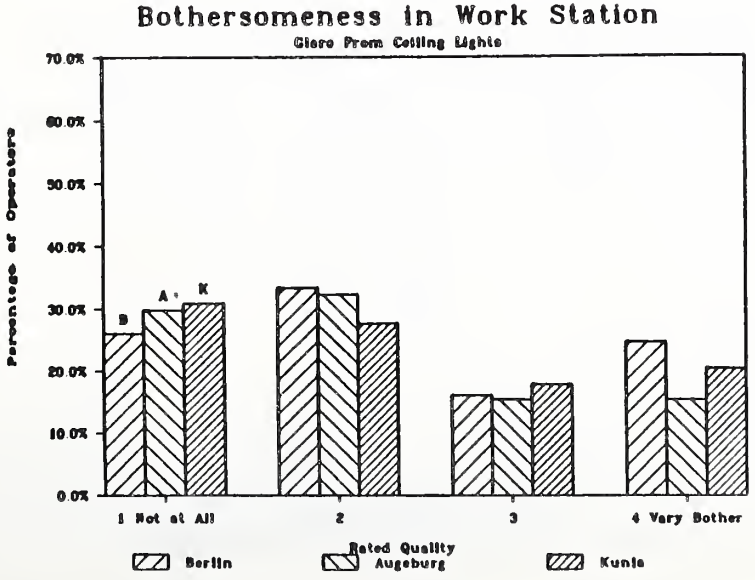
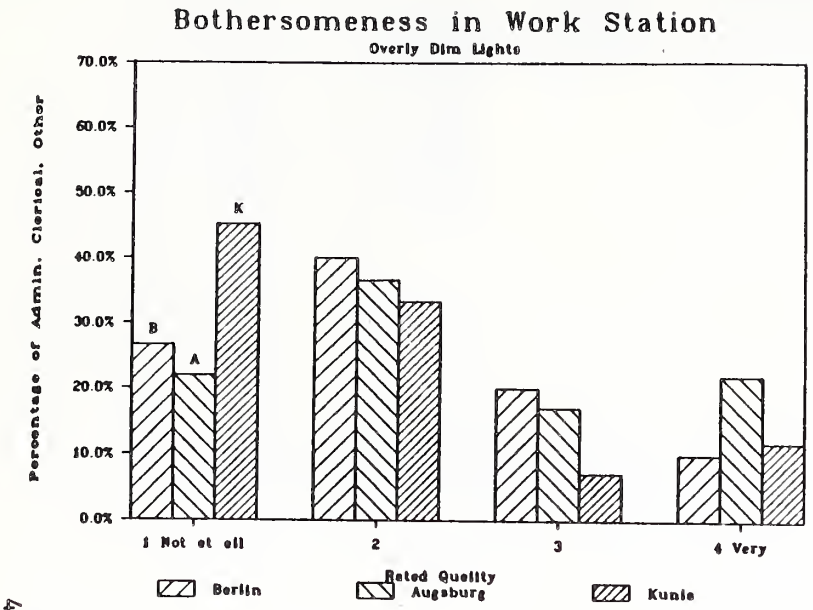
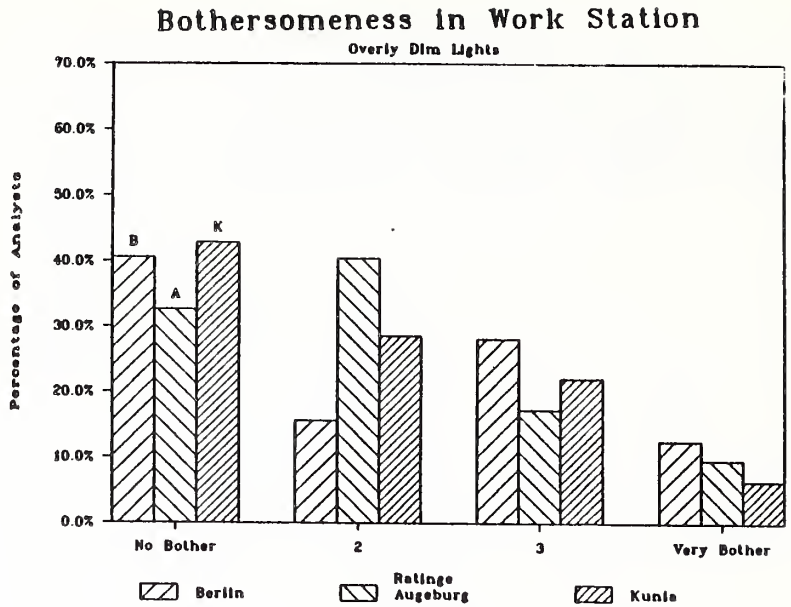


Figure 33. Percentage of People Rating the Bothersomeness of Glare from Ceiling Lights





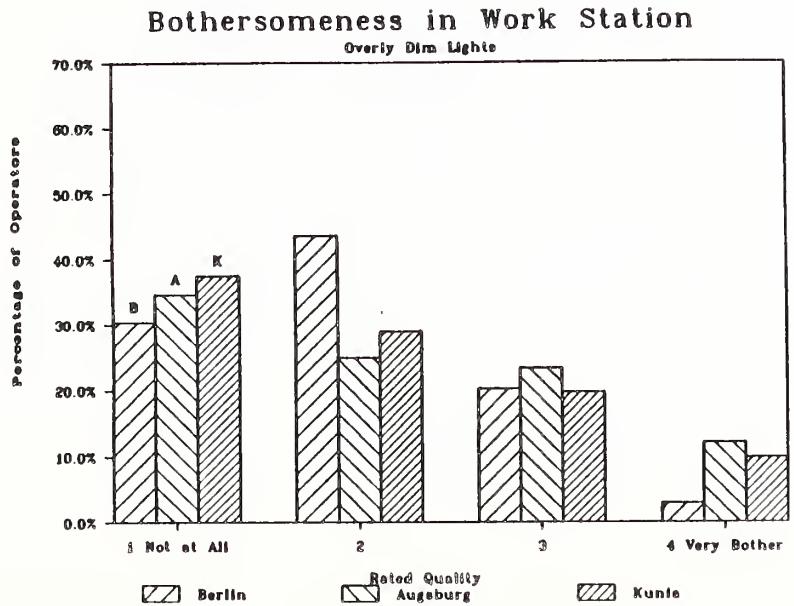
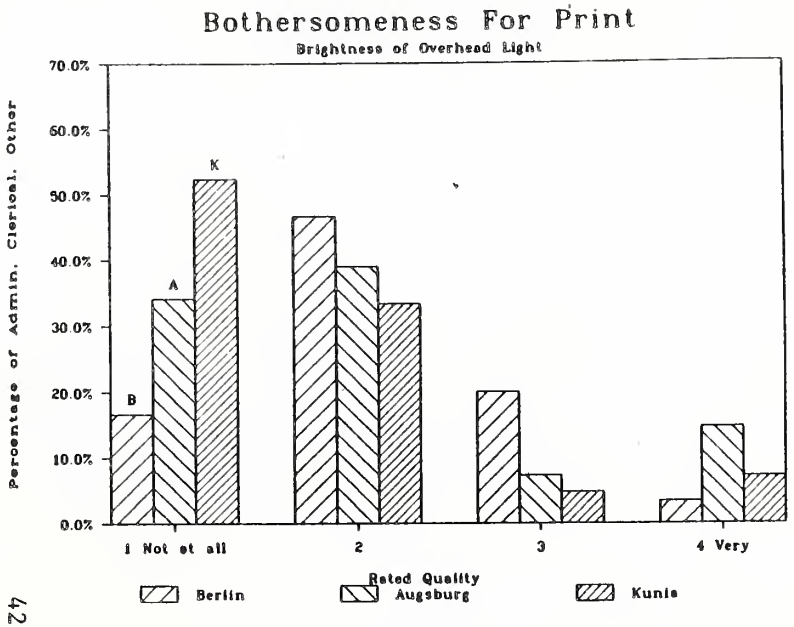
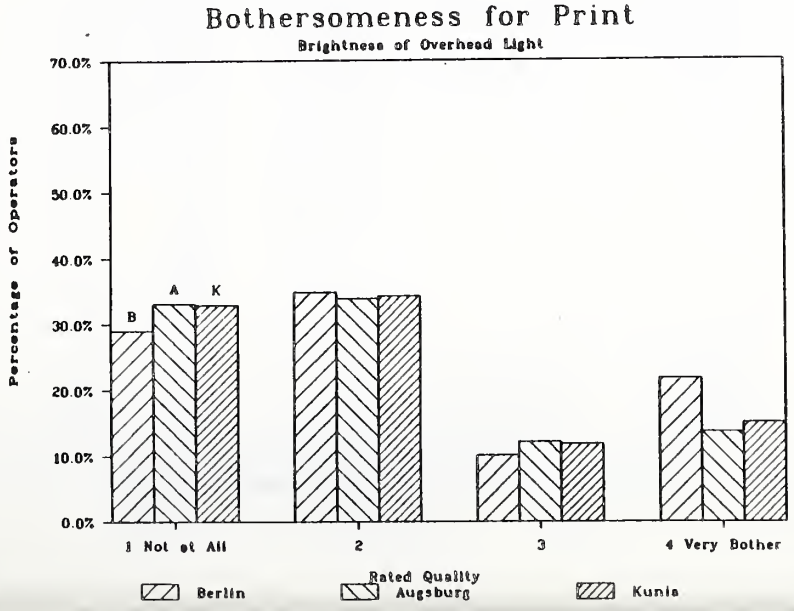


Figure 34. Percentage of People Indicating the Bothersomeness of Overly Dim Lights





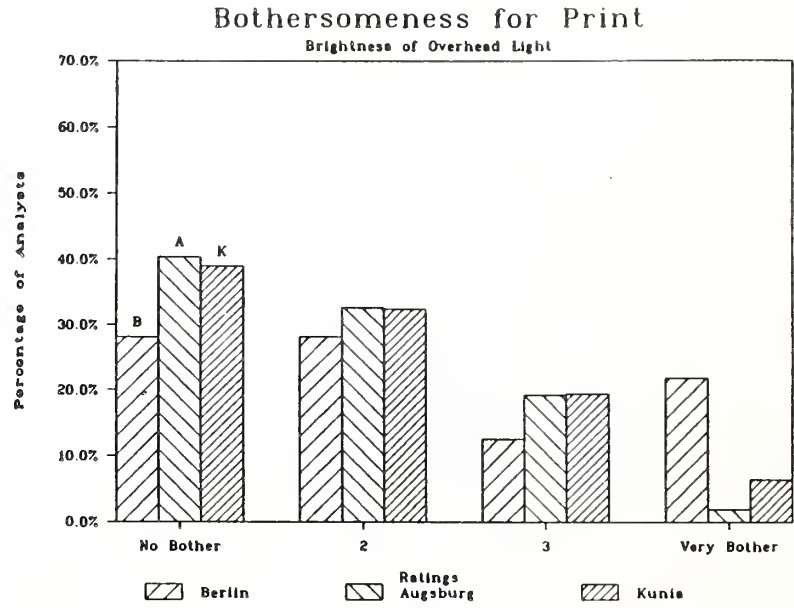
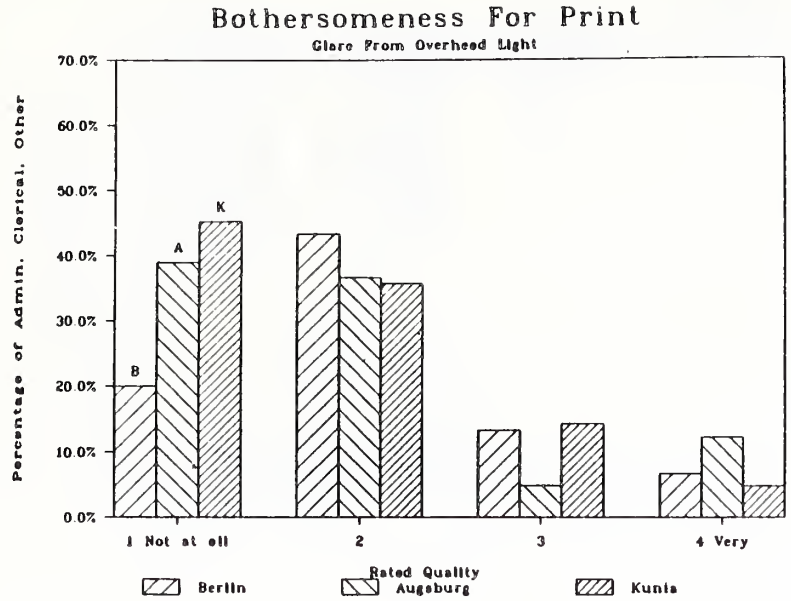
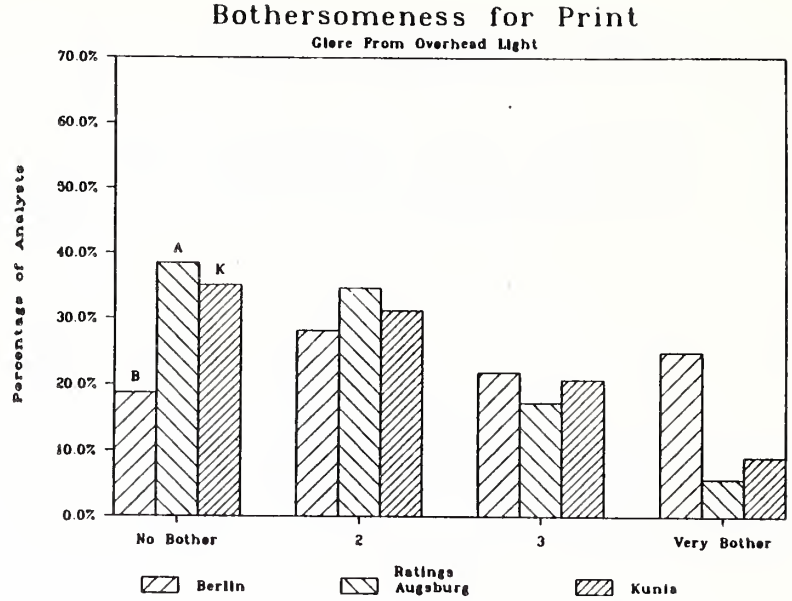


Figure 35. Percentage of People Indicating the Bothersomeness of the Brightness of the Overhead Lights for Reading Print





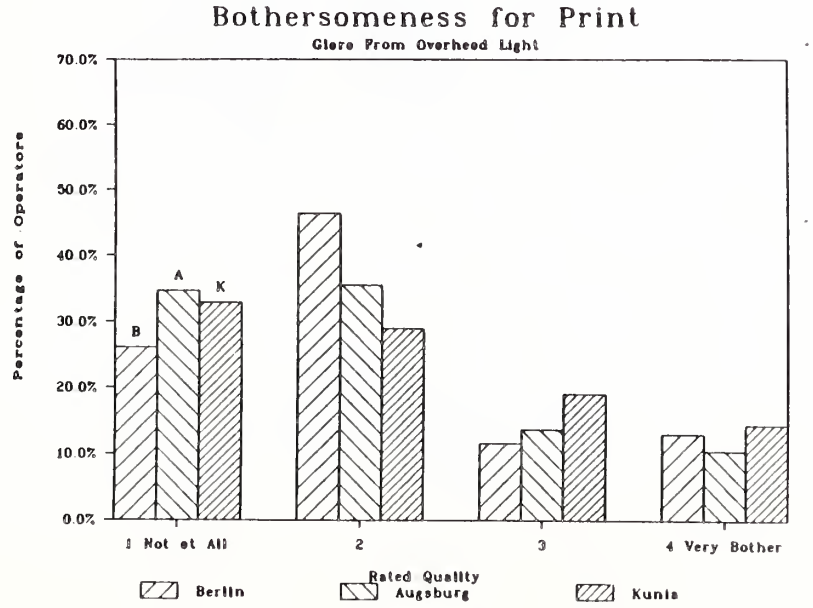
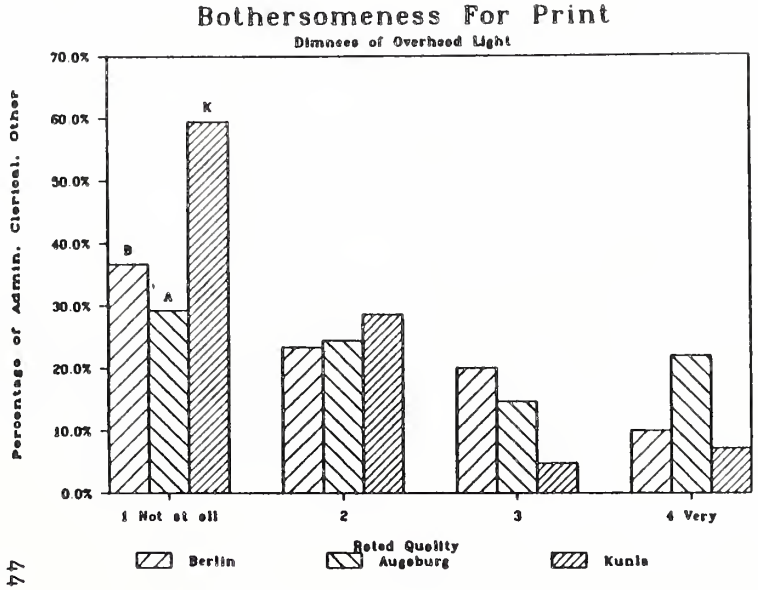
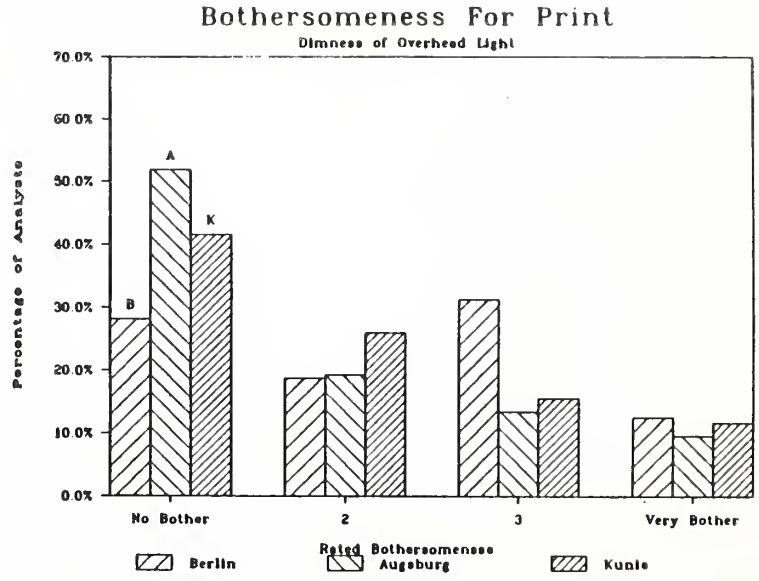


Figure 36. Percentage of People Indicating the Bothersomeness of Glare from the Overhead Lights for Reading Print





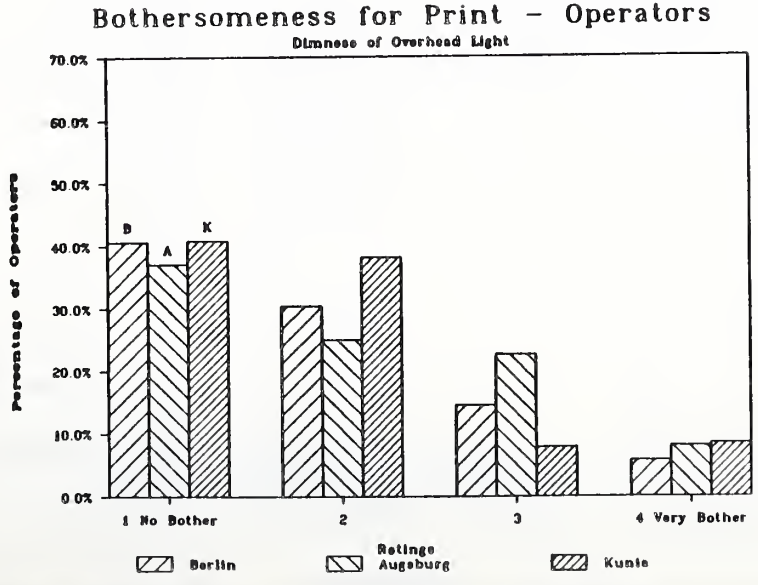
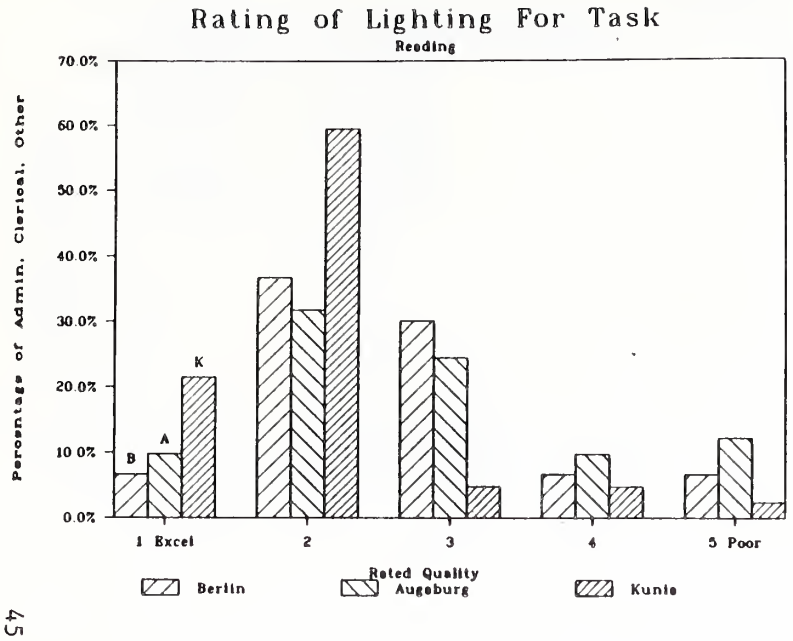
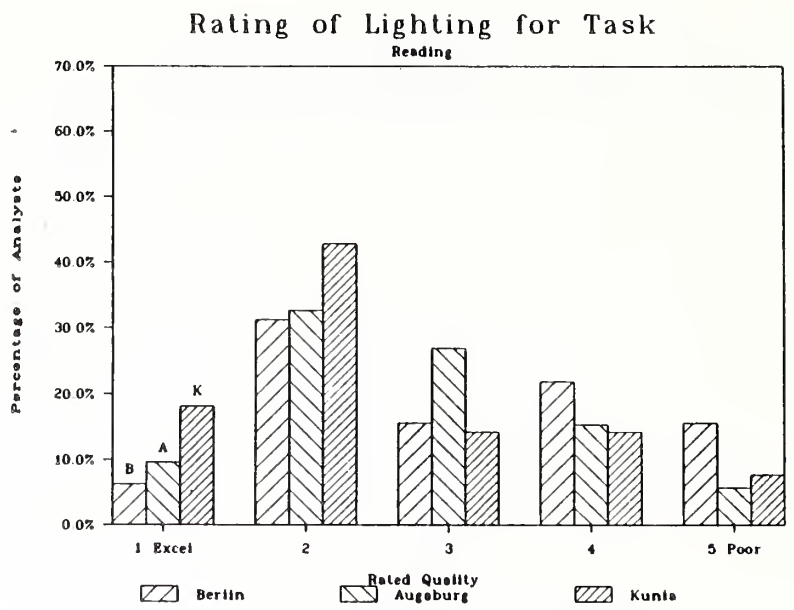


Figure 37. Percentage of People Indicating that the Dimness of Overhead Lights is Bothersome for Reading Print





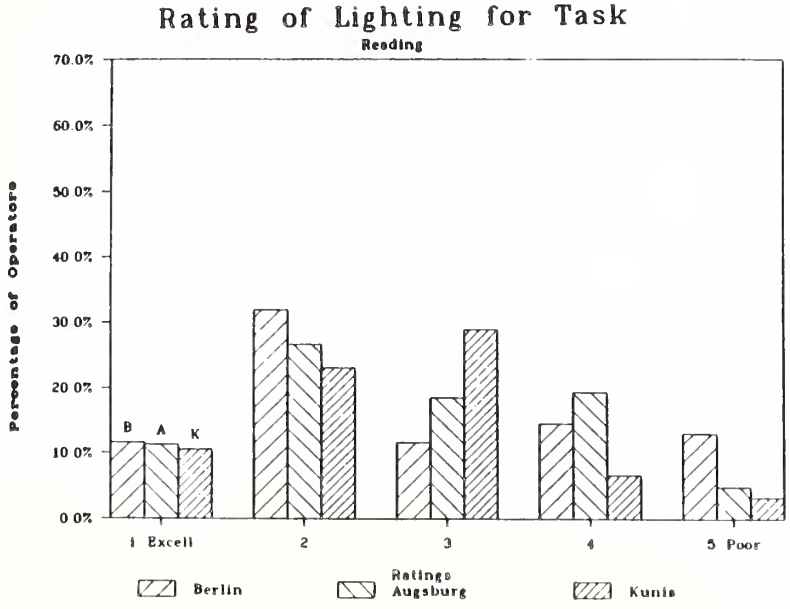
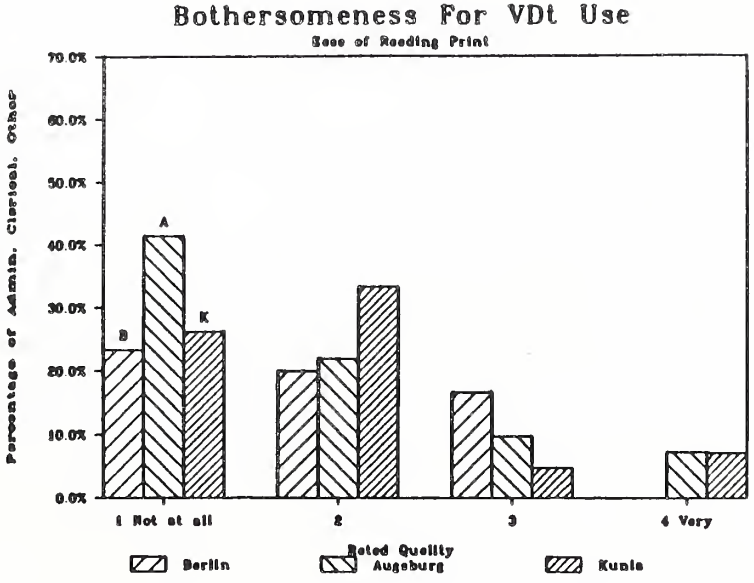
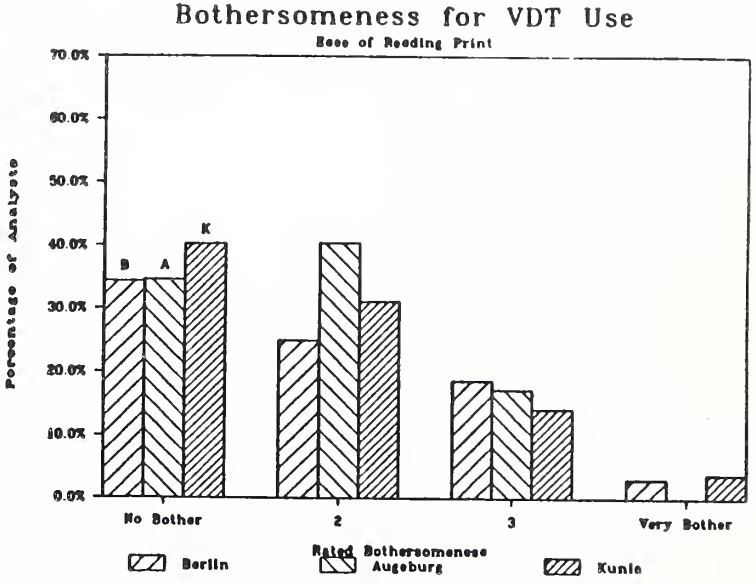


Figure 38. Percentage of People Rating the Quality of Lighting for Reading





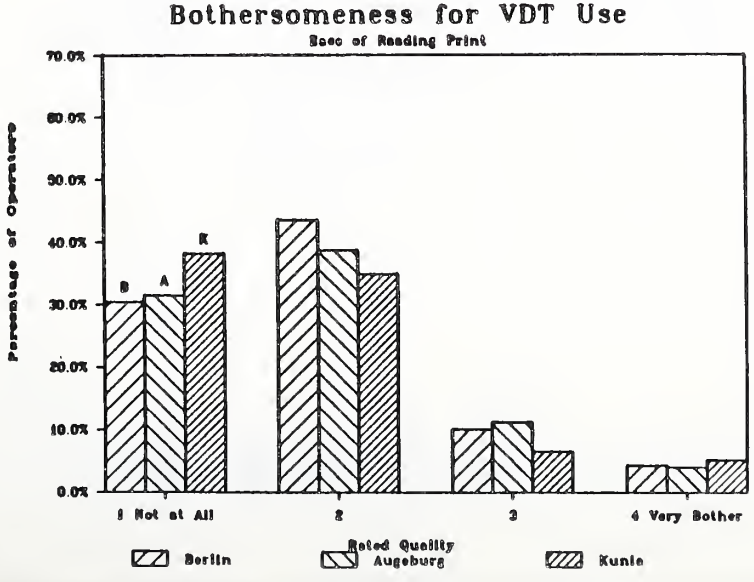
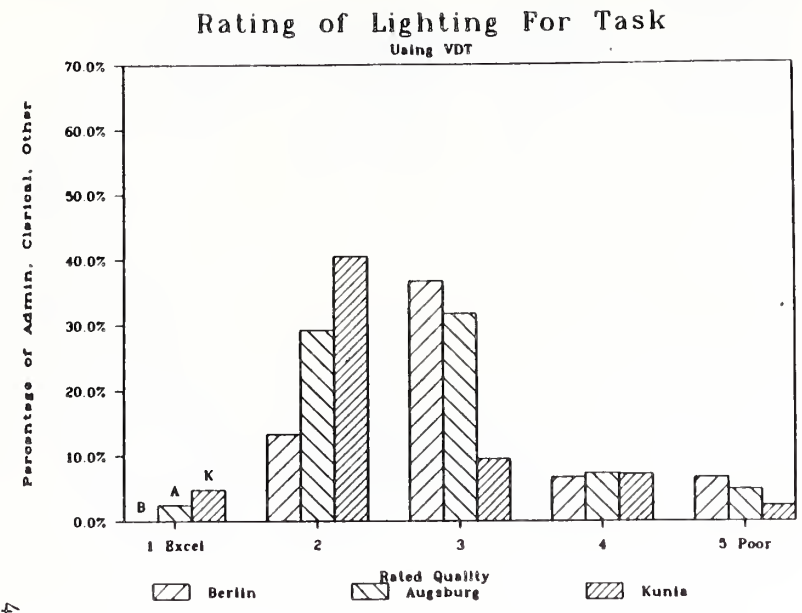
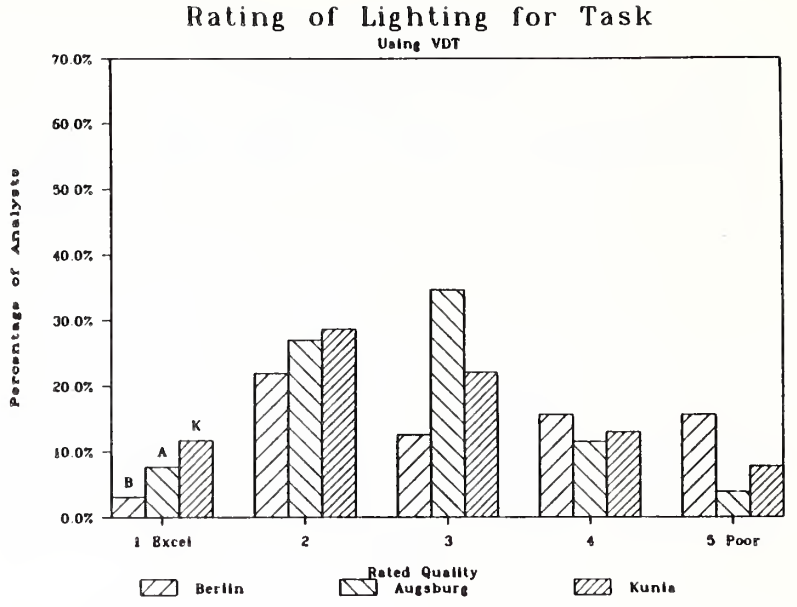


Figure 39. Percentage of People Using VDTS who find Reading Printed Tasks to be Bothersome





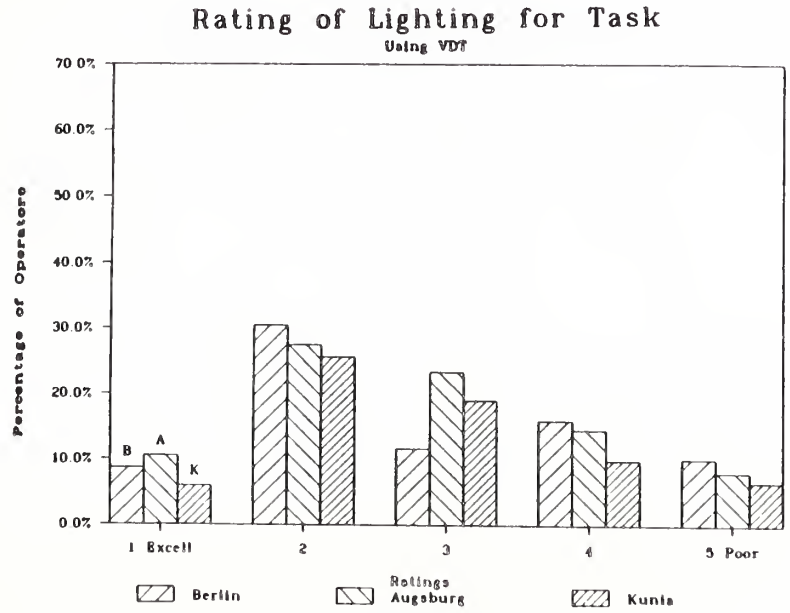
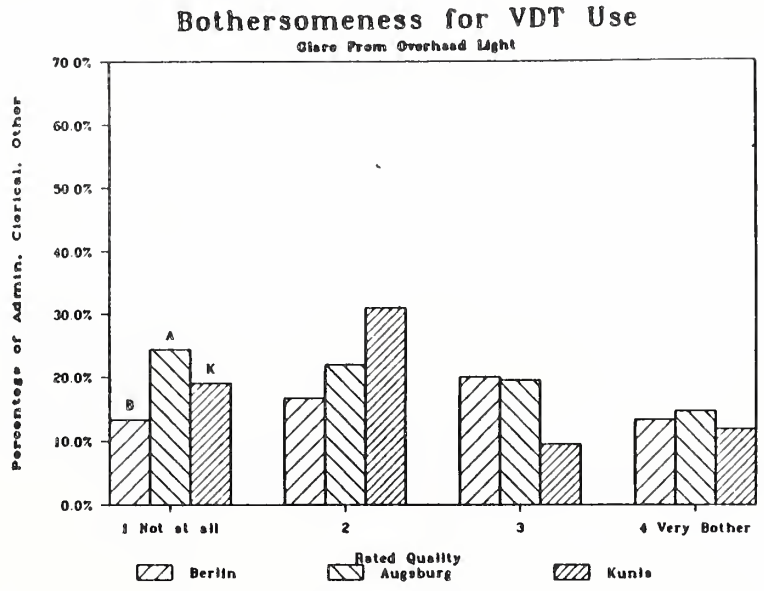
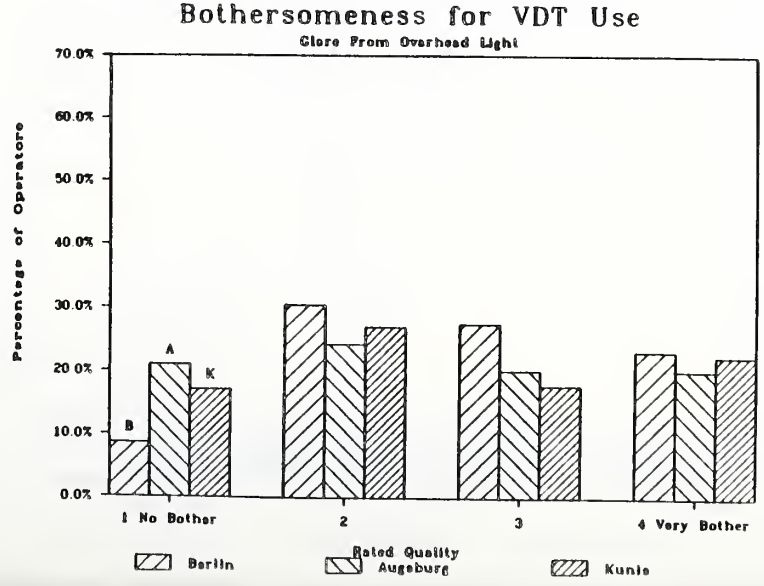


Figure 40. Percentage of People Rating Lighting Quality for using a VDT





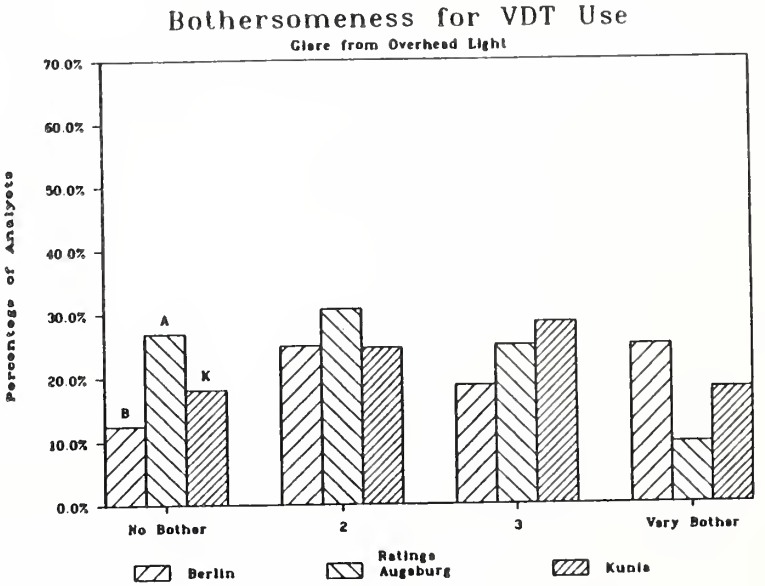
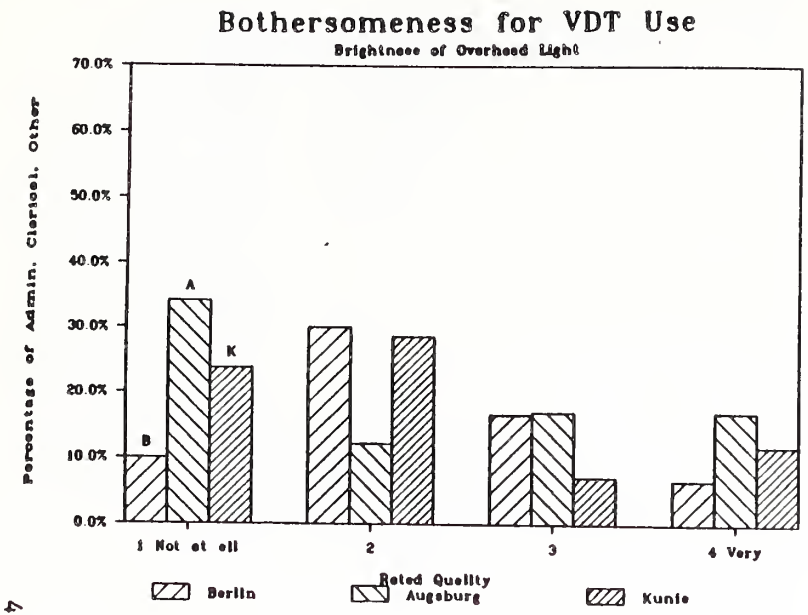
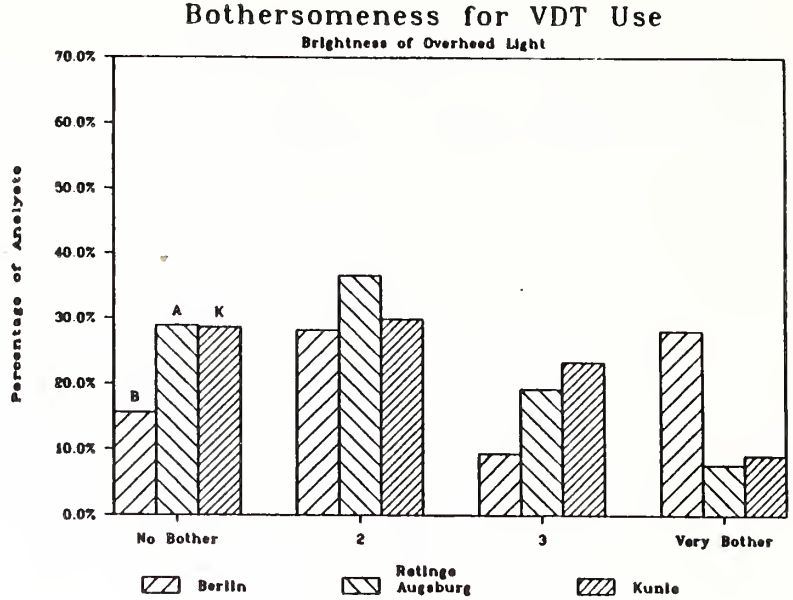


Figure 41. Percentage of People Indicating the Bothersomeness for VDT use of Glare From the Overhead Lights





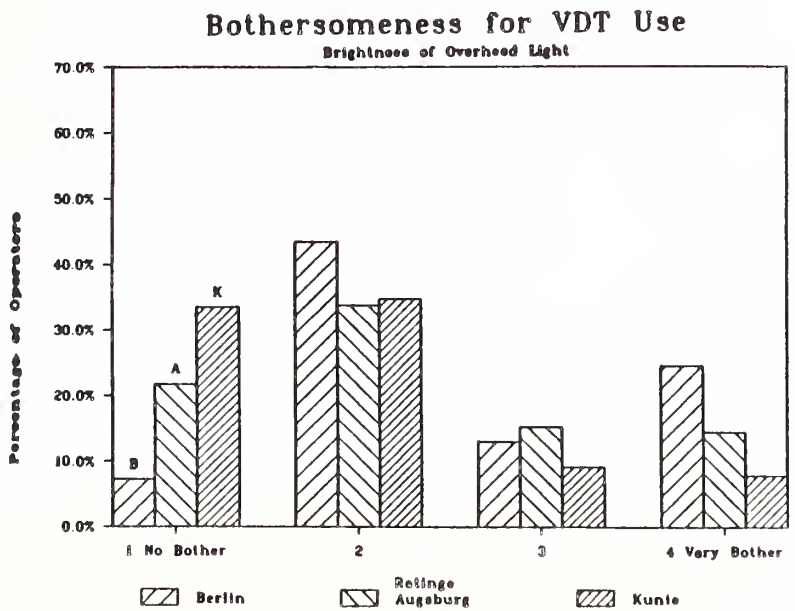
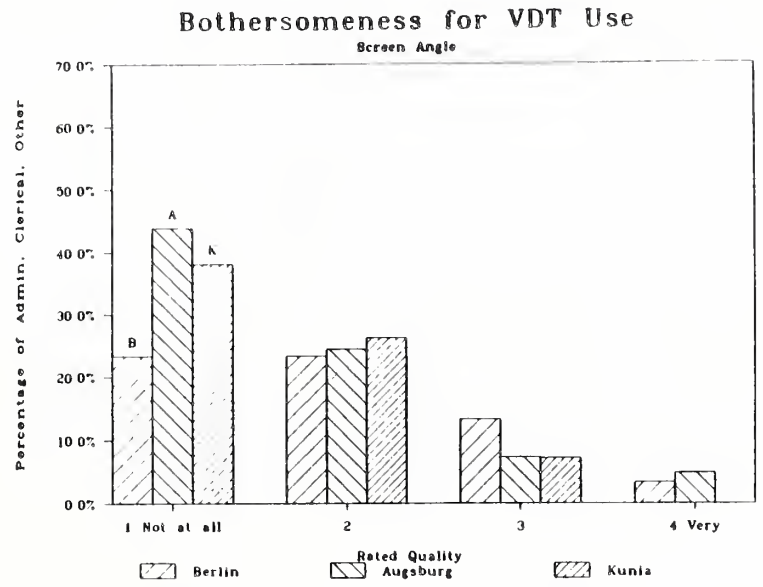
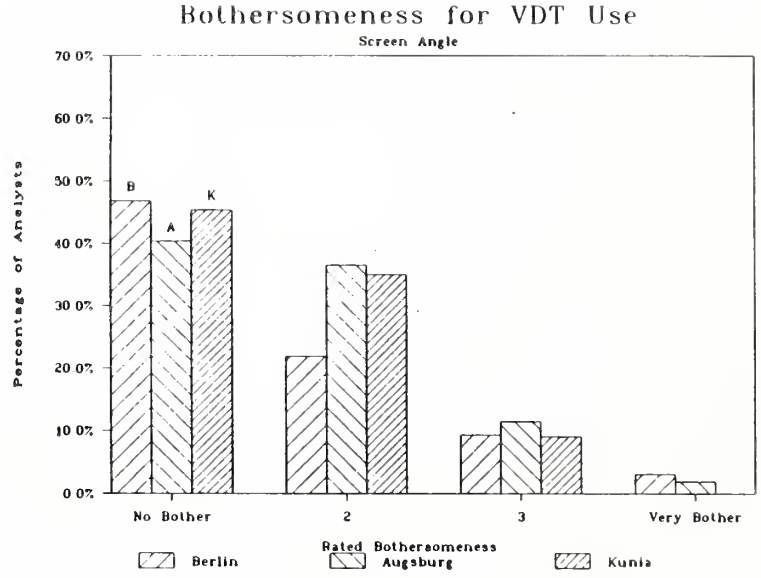


Figure 42. Percentage of People Indicating the Bothersomeness of the Overhead Light for Using VDT





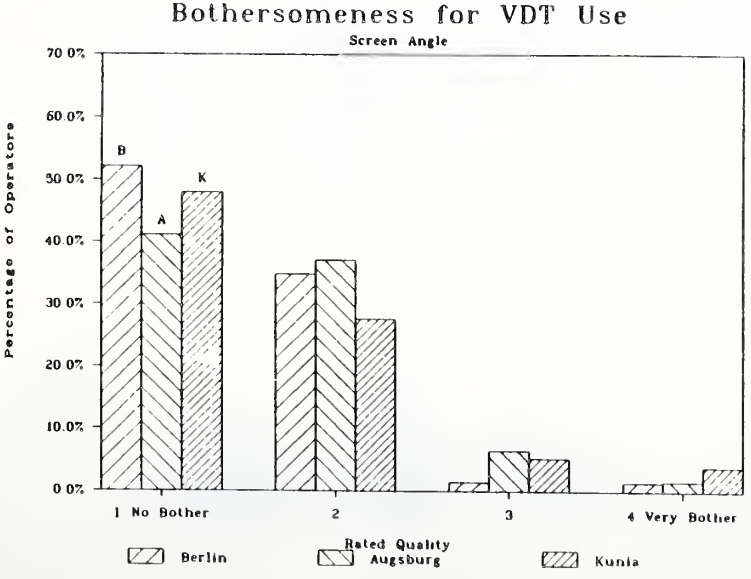
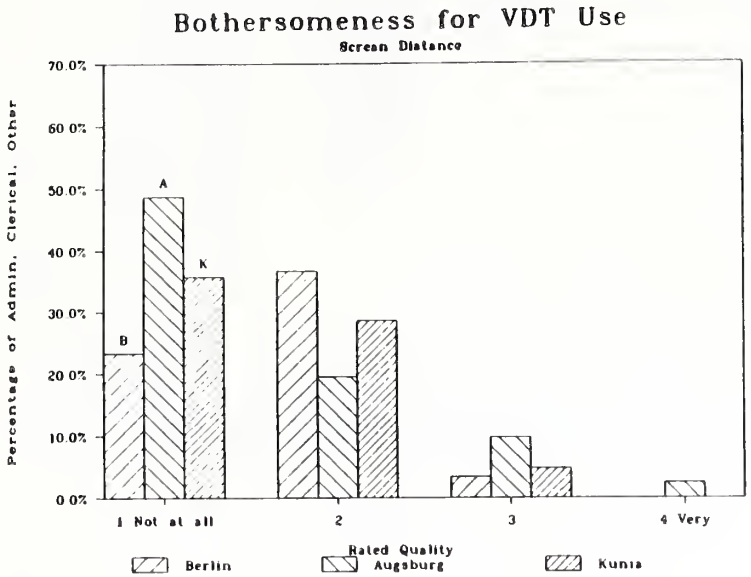
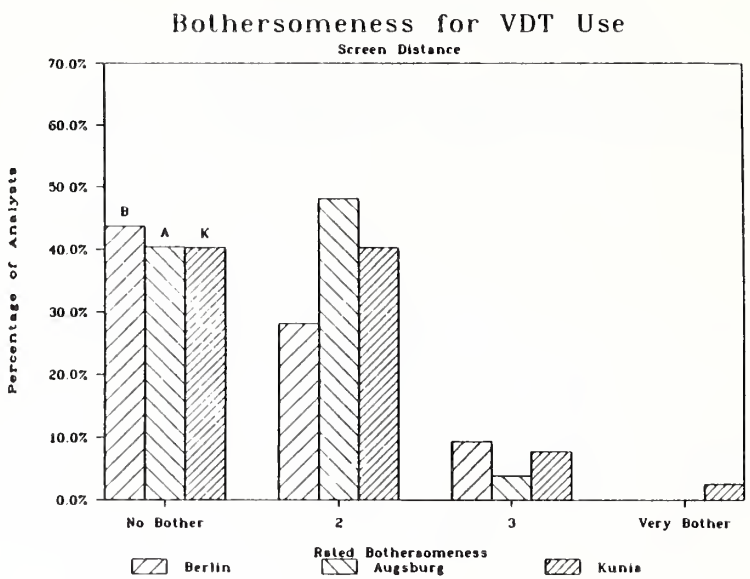


Figure 43. The Percentage of People Indicating the Bothersomeness of the Screen Angle for Using VDT's





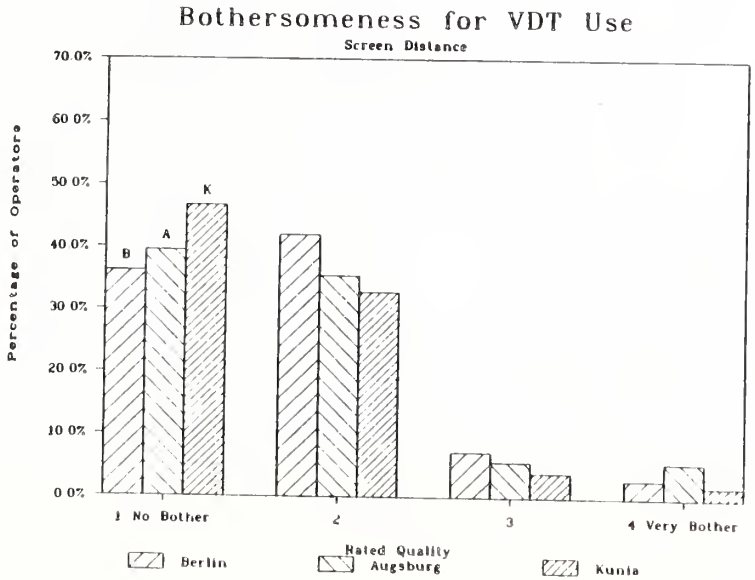
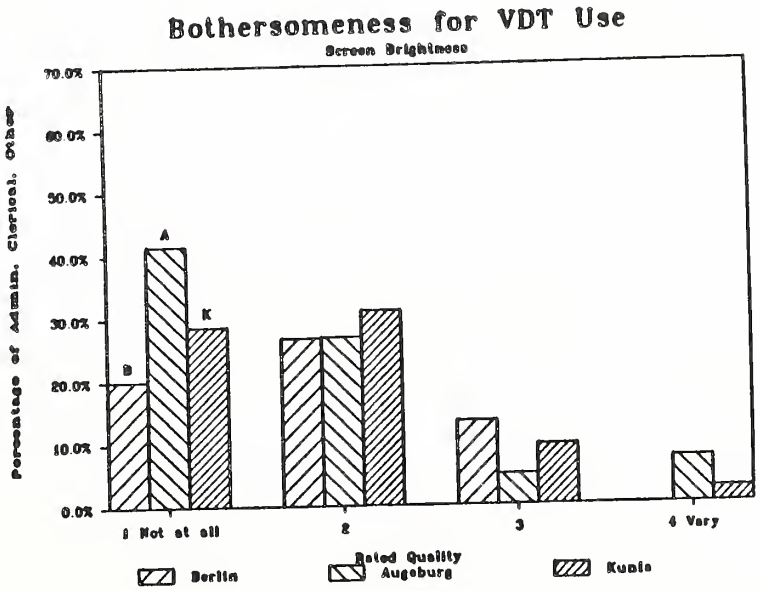
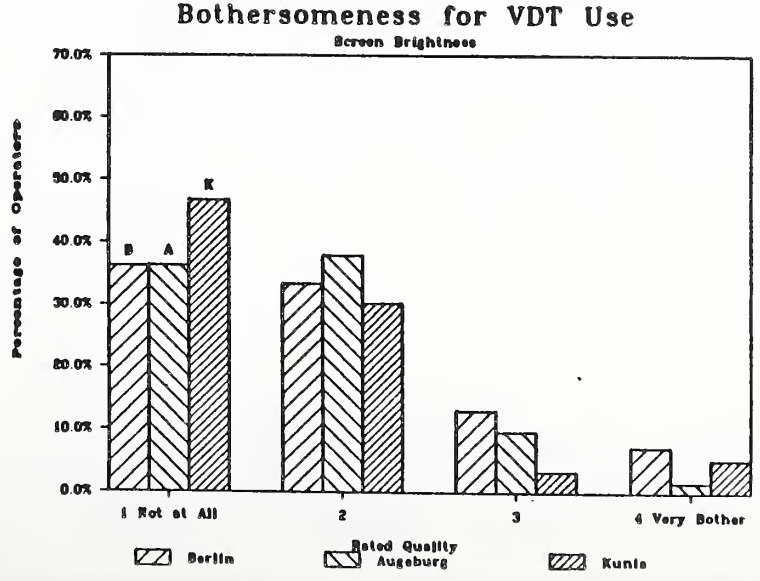


Figure 44. Percentage of People Indicating the Bothersomeness of the Distance of the Screen for Using VDT's





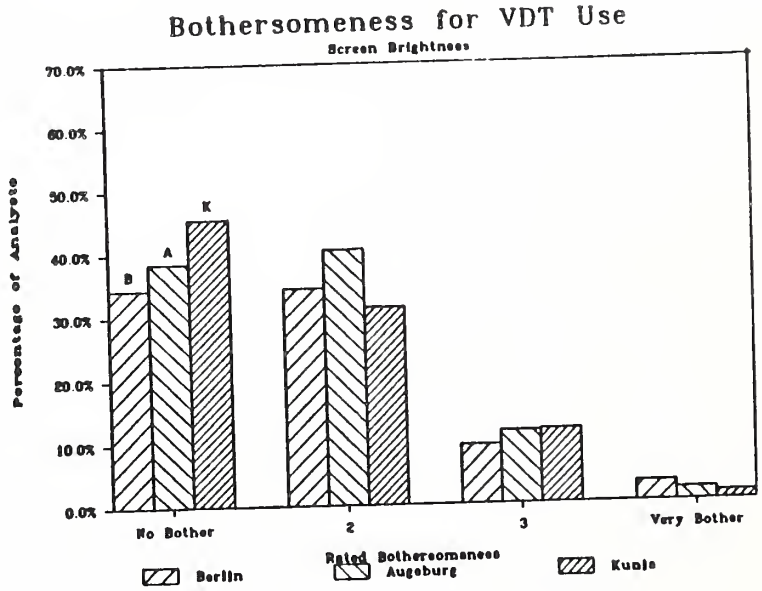
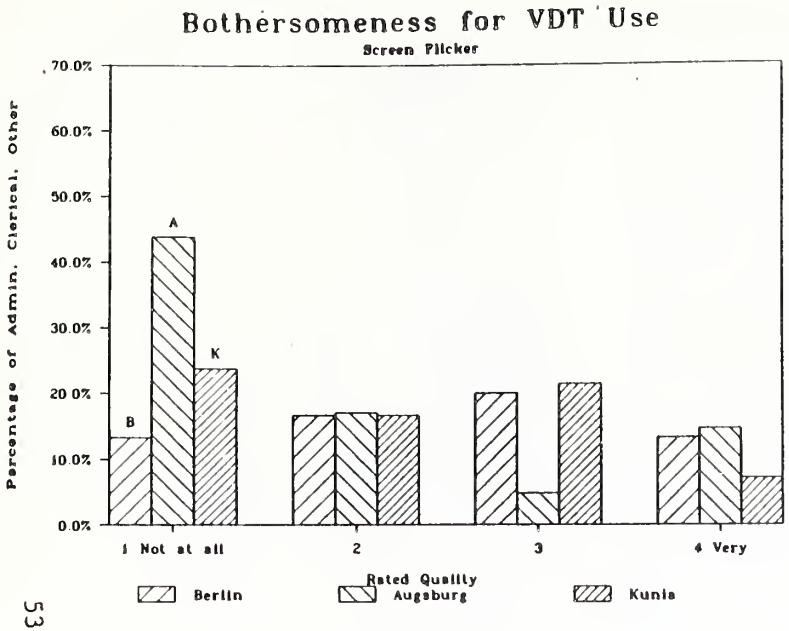
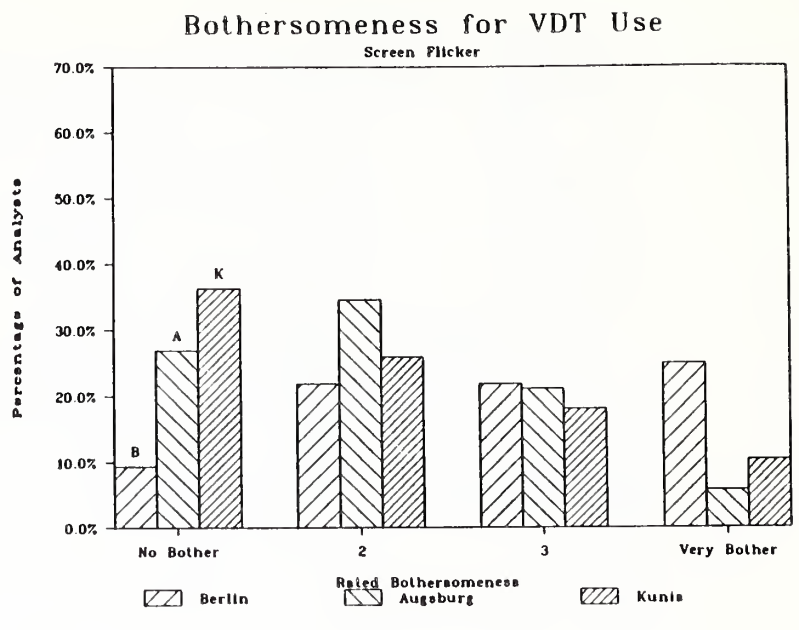


Figure 45. Percentage of People Indicating the Bothersomeness of Screen Brightness of VDT use





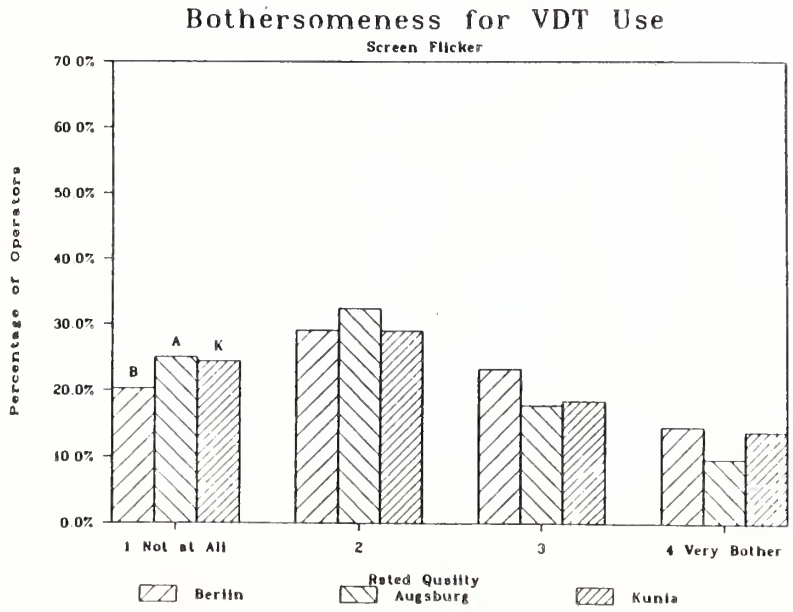


Figure 46. Percentage of People Indicating the Bothersomeness of Screen Flicker for Using the VDT's

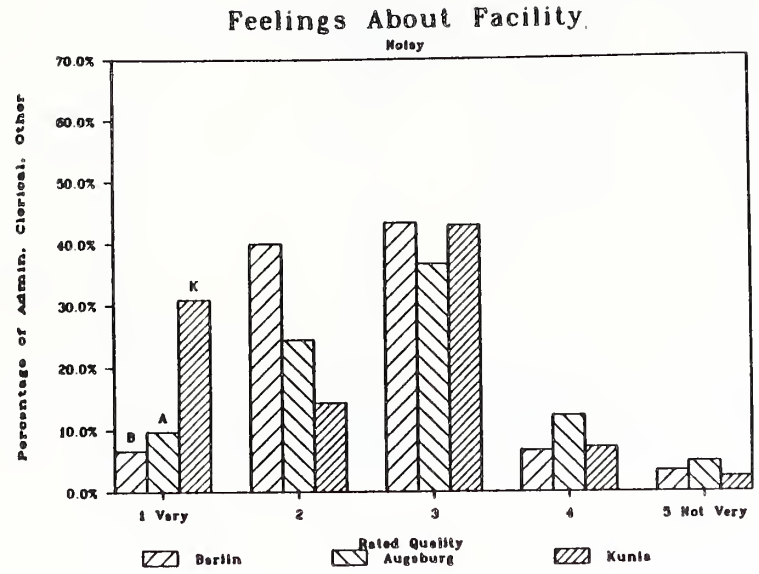
Responses to the lighting conditions suggest that the most salient lighting issue is the ability to adjust light for the task. All respondents reported it to be "very poor". Their responses suggest that the use of local task lighting to control the amount and position of the light would greatly ease the complaints about the lighting and improve the ability to do visual tasks.

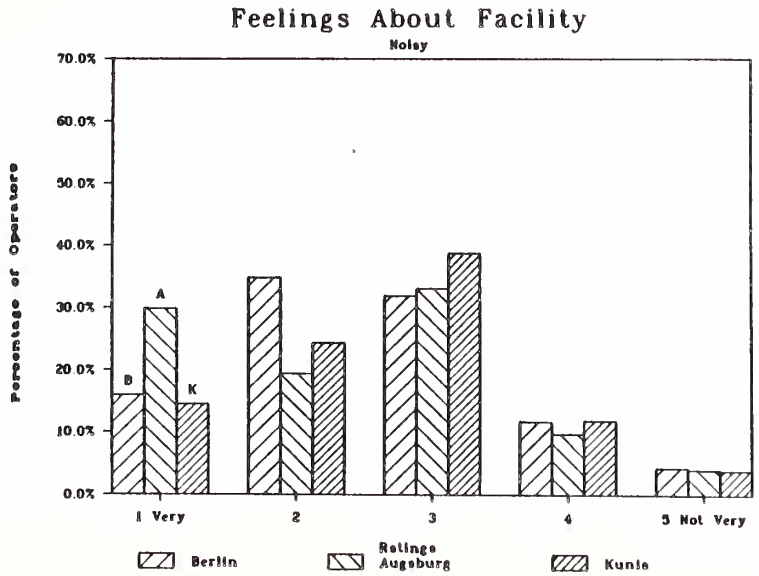
3.4 Response to Noise

Figures 47 to 52 deal with noise conditions. Figure 47 indicates that most respondents considered their facility to be "noisy" , but only 10 to 30% regarded it as "very noisy". Another 20 to 40% considered it to be somewhat noisy, while 30 to 40% were neutral. Figure 48 presents data that indicate that respondents felt that noise hindered their job performance somewhat, but not a lot. Thus, about 30% of all analysts and 30% of the administrators at Berlin and Augsburg believed that noise hinders performance somewhat, but only about 5% of all respondents indicated that it is "very true" that noise is a hindrance. Operators at all sites were the most positive with 20 to 30% indicating that noise did not impair their job performance. Figure 49 indicates that printer noise was very bothersome to about 20% of the analysts, 15% of the administrators, and less than 10% of the operators. This finding obviously depends on nearness to the printer since high noise levels were measured only near a few printers. Similarly, Figure 50 suggests equipment noise was "not at all", or "not very" bothersome to 60 to 80% of the respondents.

Data from section 5 on noise measures indicate that, in general, noise levels were reasonable - between 60 and 65 dbA. In several locations at all three sites, however, printers were measured at levels between 80 and 86 dbA - a level loud enough to cause annoyance and possible hearing damage for those working near the printer, if this were a permanent work station. A subjective assessment by the experimenter also given in section 5 indicated that ventilation noise (particularly in operations), conversations, and printers (particularly in analysis) were potentially bothersome at all three sites. Such noise will not damage hearing but it might interrupt trains of thought and decrease work output.

Figure 51 suggests conversations were "somewhat bothersome" to 40 to 45% of the administrators at Augsburg and Kunia but only to 25% of those in Berlin. Again, operators appeared to be the least bothered, with about 70% indicating that noise is "not at all" or "not very" bothersome. Finally, figure 52 suggests that ringing telephones were bothersome to analysts and to administrators, particularly those in Berlin, but not to operators. (Operators are shielded from office noises by their headphones, but are exposed to headphone noise.)





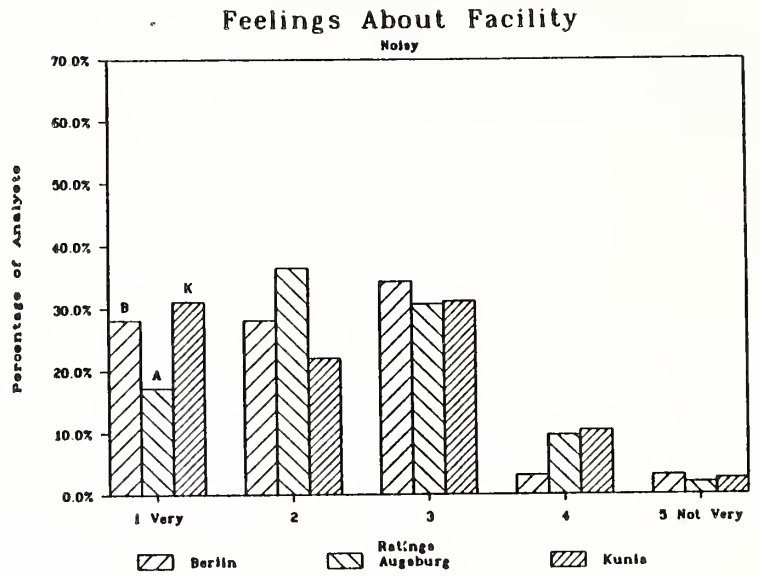
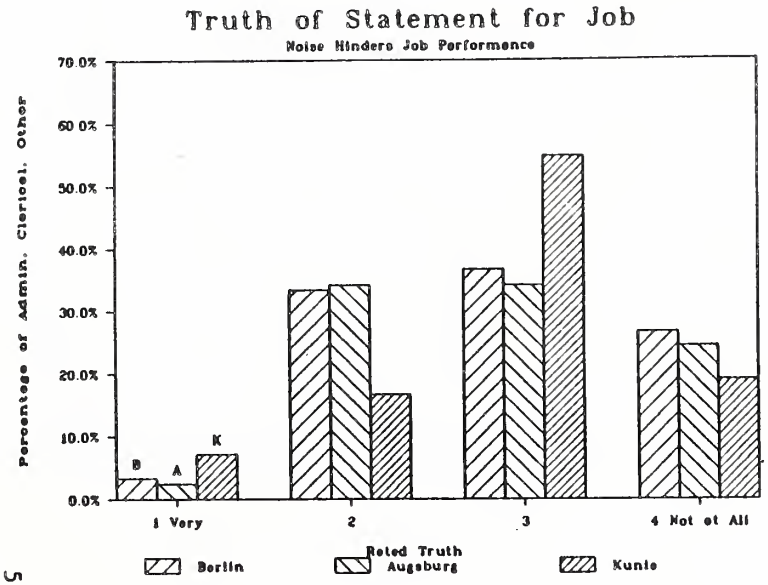
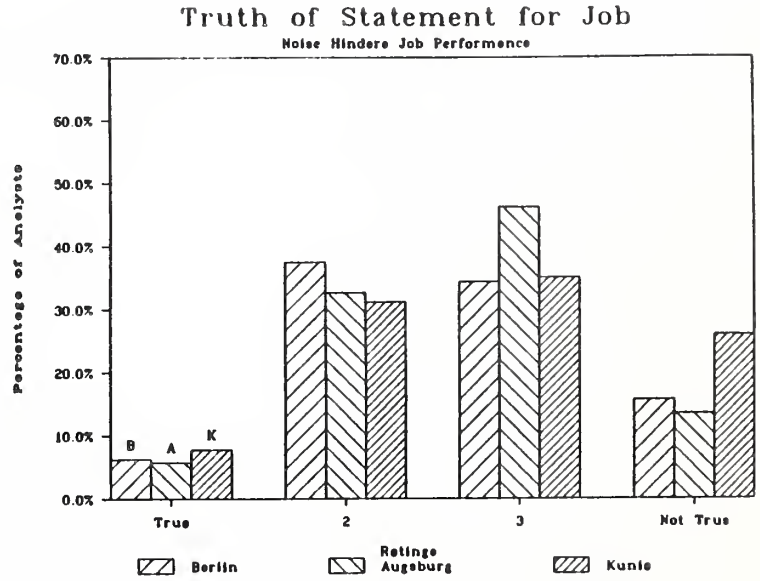


Figure 47. Percentage of People Indicating that they Feel that the Facility is Noisy





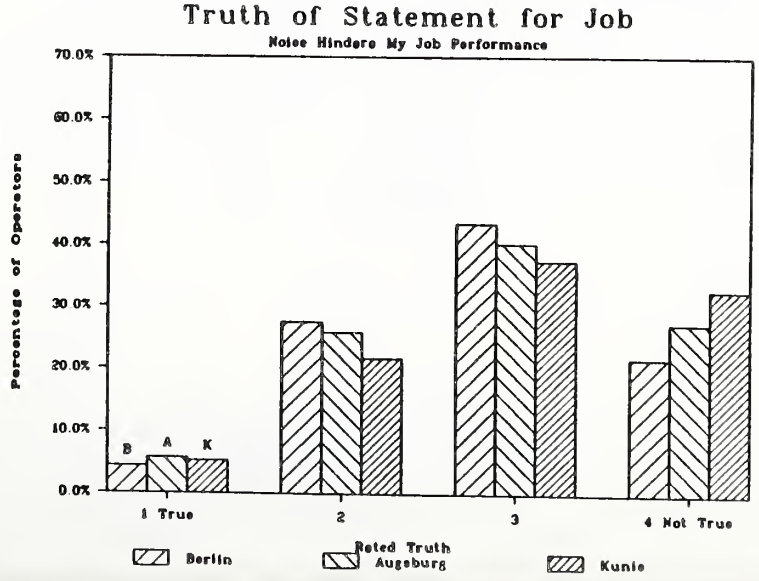
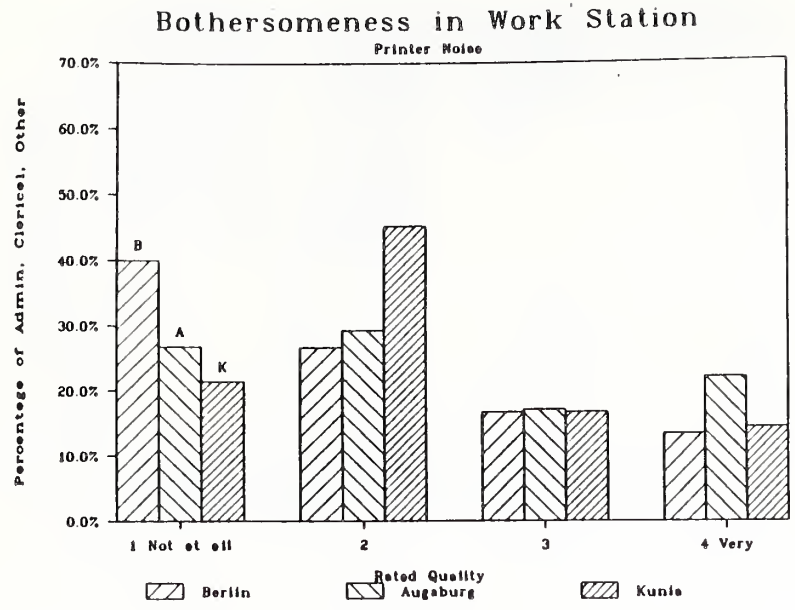
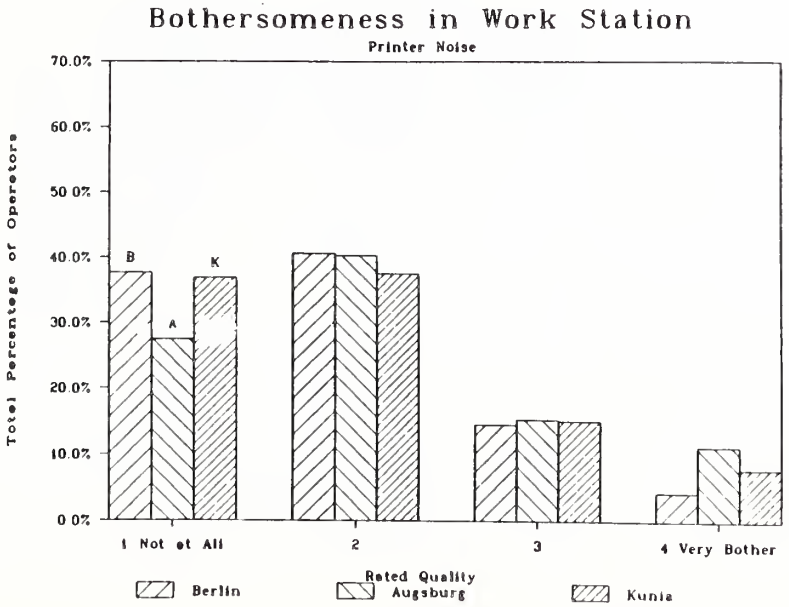


Figure 48. Percentage of People Indicating that Noise Hinders their Ability to do their Job





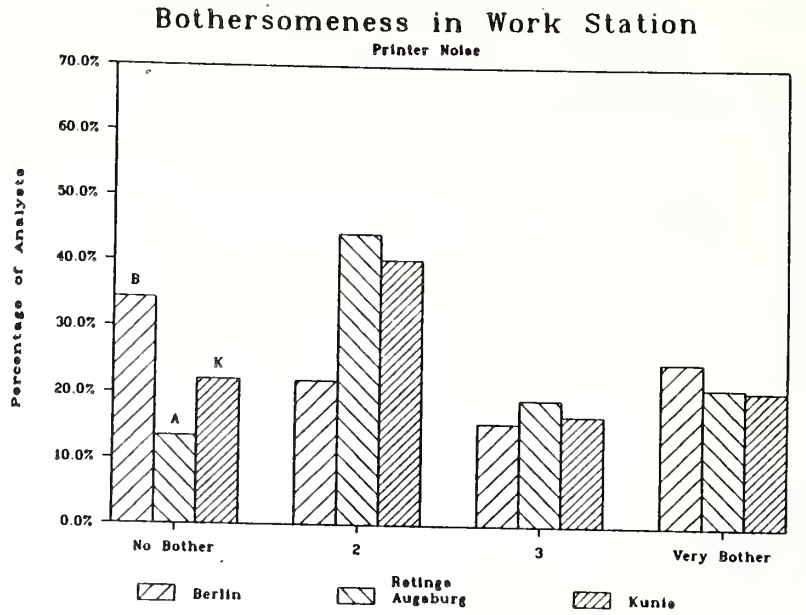
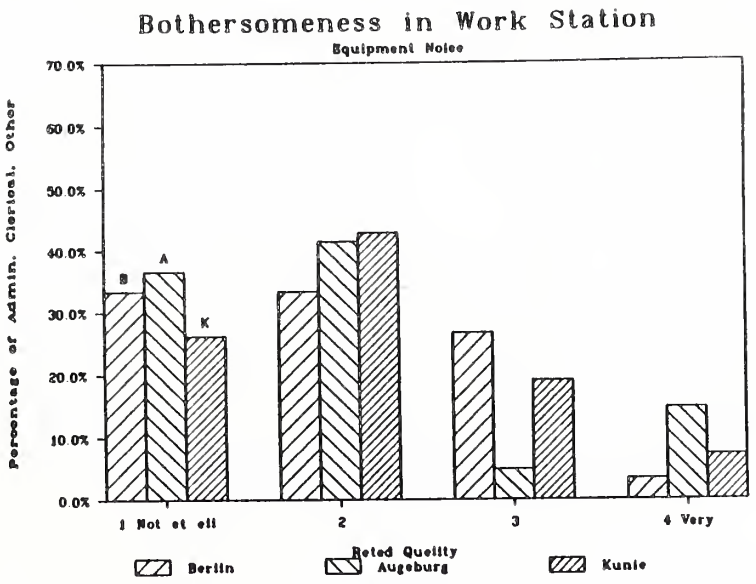
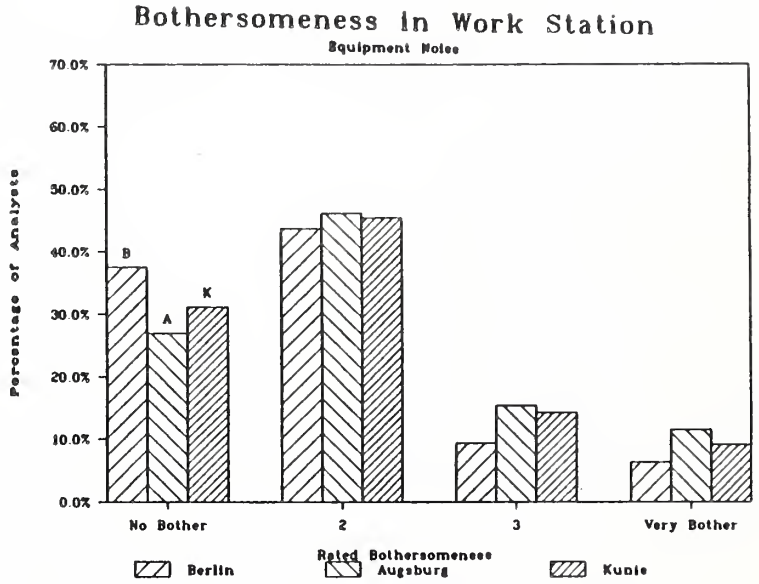


Figure 49. Percentage of People Indicating that Printer Noise is Bothersome





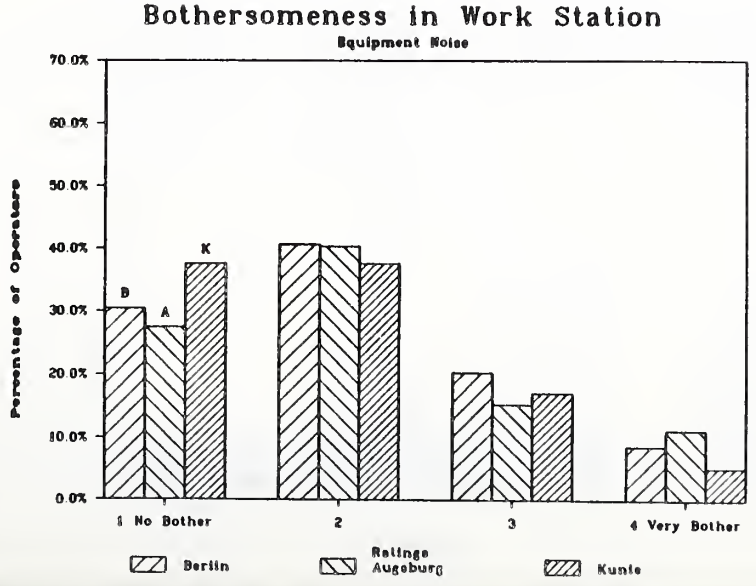
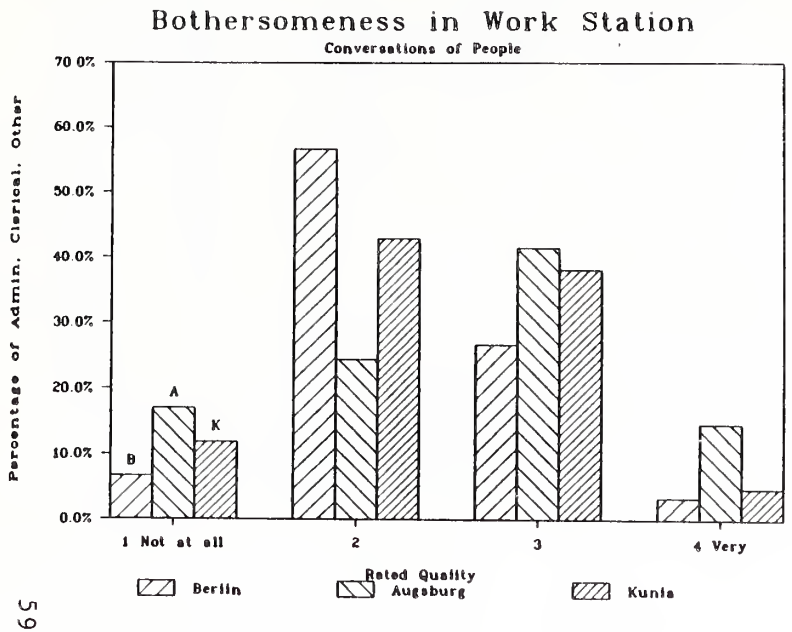
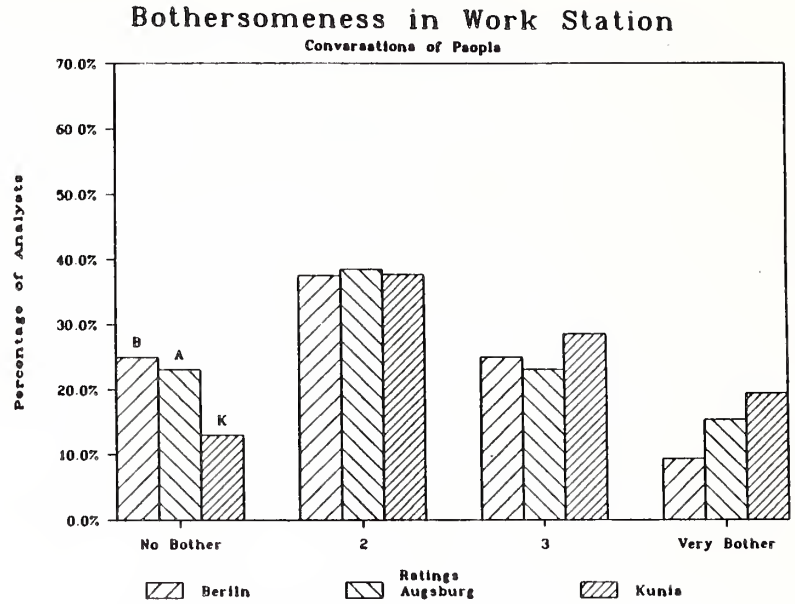


Figure 50. Percentage of People Indicating that Equipment Noise is Bothersome





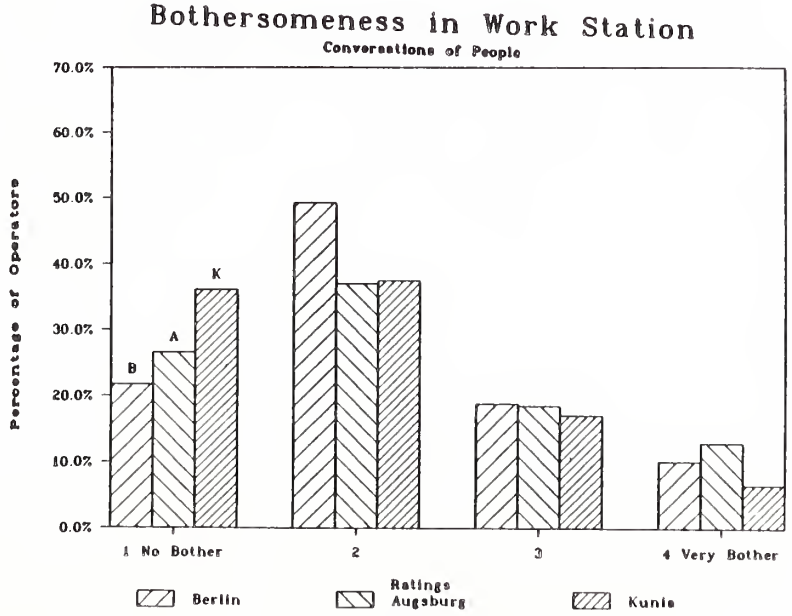
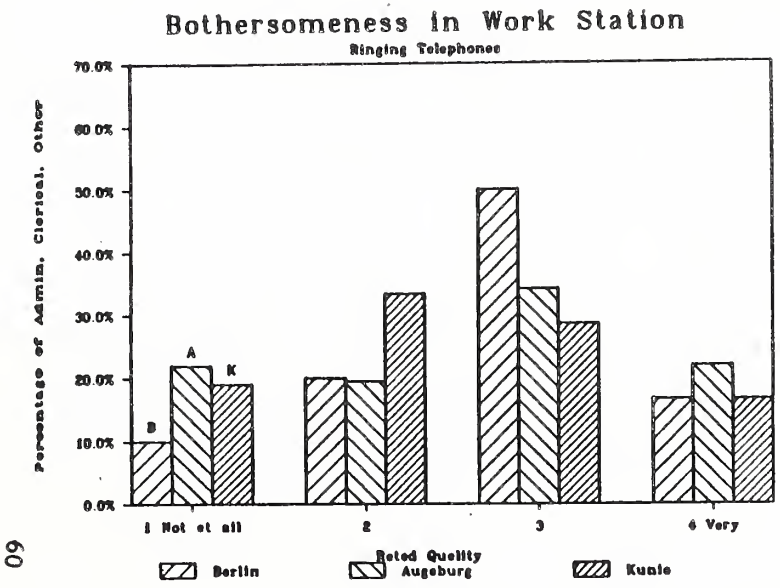
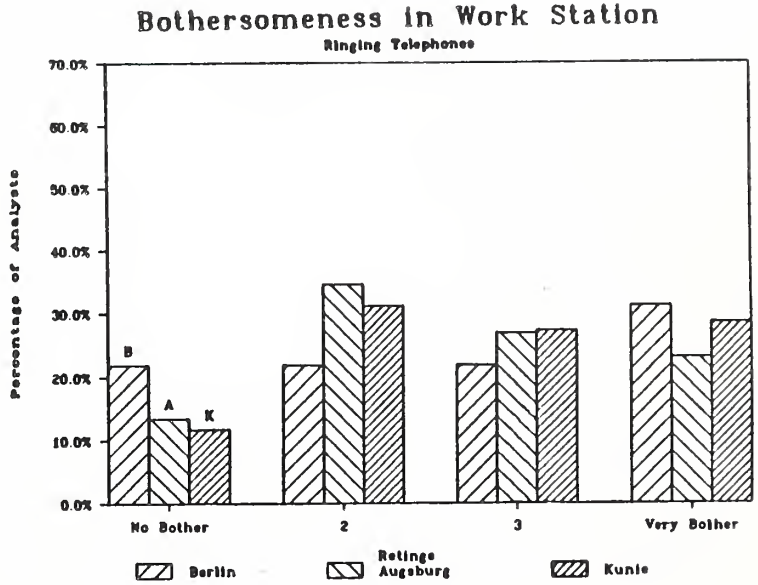


Figure 51. Percentage of People Indicating the Conversations of Other People are Bothersome





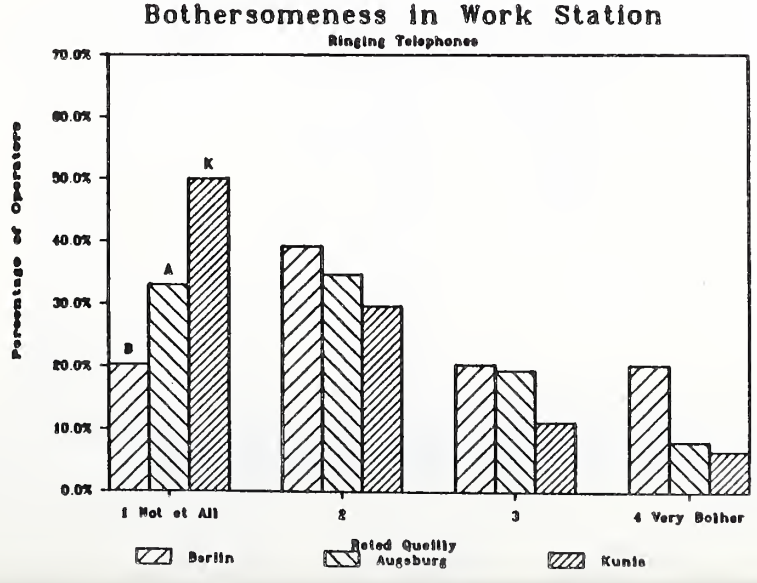
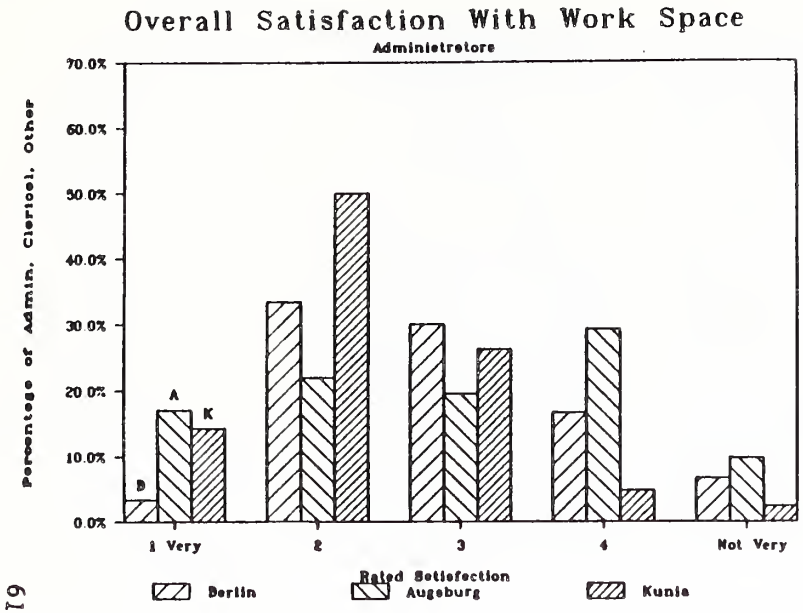
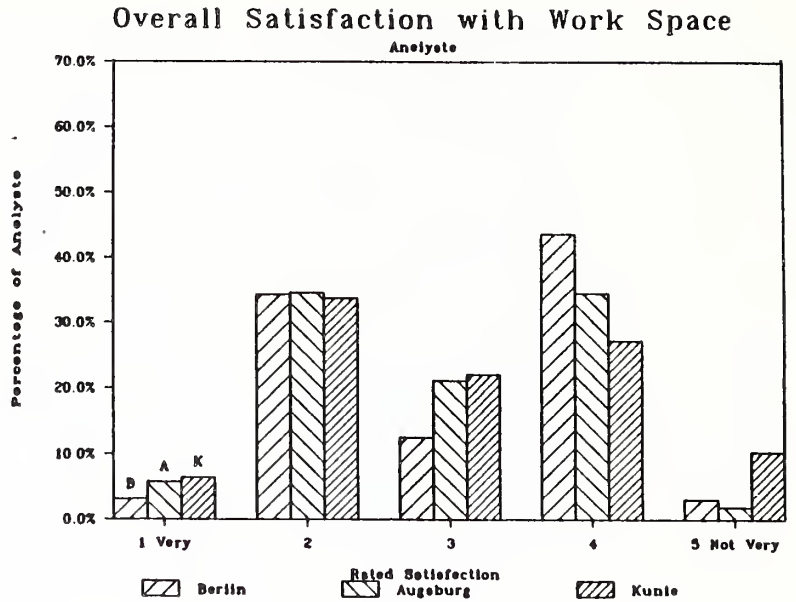


Figure 52. Percentage of People Indicating that Ringing Telephones are Bothersome





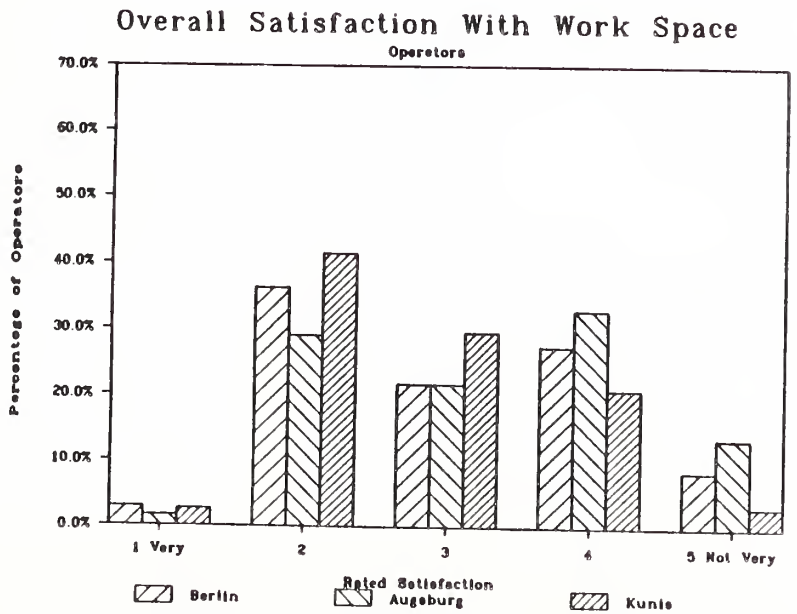


Figure 53. Percentage of People Expressing Overall Satisfaciton with their Work Space for each Job Category

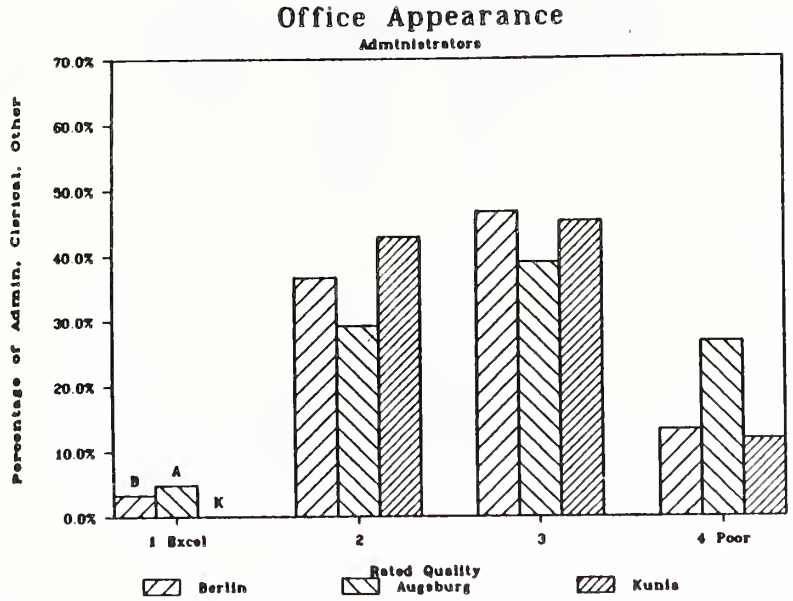
3.5 General Response to the Space

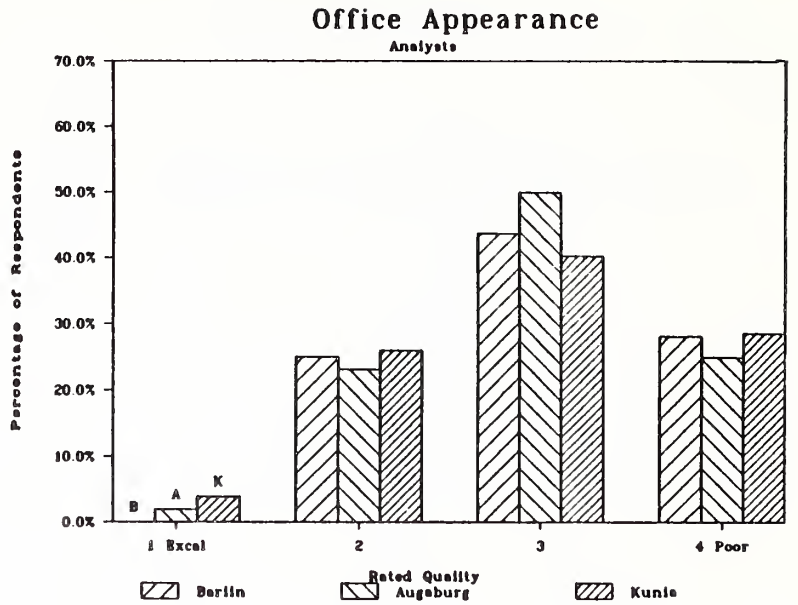
Figures 53 to 66 present data on more general reactions to the spaces, including impact of windowless spaces, colors, general impressions, and overall satisfaction. Figure 53 demonstrates noticeable differences between respondents in overall workspace satisfaction. Administrators at Kunia and Berlin appeared to be the most satisfied with their workspaces, with more than 60% of those at Kunia indicating they were "fairly" to "very satisfied". Yet, in Augsburg about 35% of the administrators were "not very satisfied". Operators viewed their spaces as "fairly satisfactory", "neutral", or "not very satisfactory". Analysts at all sites tended not to be satisfied, with 40 to 50% rating their spaces as "not very" or "not at all" satisfactory.

Figure 54 indicates that the majority of respondents believed the overall appearance of their workspaces was only "fair", with 20 to 25% of all analysts rating it as "poor". Only the administrators in Kunia considered it to be "pretty good". Less than 5% of all respondents considered their space "excellent". All respondents did consider their facility to be "adequate" rather than "inadequate", as seen by the pattern of responses in figure 55. The next figure, 56, indicates that people generally felt their facility was neither "pleasant" nor "unpleasant", except for Kunia administrators who tended to rate it as "somewhat pleasant". Operators viewed their facility as somewhat more "unpleasant" than "pleasant".

Figure 57 suggests that respondents at all sites were neutral or negative about building maintenance, with all analysts, and administrators at Augsburg and Berlin being more negative than positive. Figure 58 reveals that all respondents were neutral about their facility being either "better" or "worse" than others. Figure 59 suggests that the analysts, particularly those in Kunia, felt their work area was especially "confined", although less than 20% of any group rated their area as "spacious". Figure 60 indicates that virtually all analysts found their workspaces unstimulating but very few respondents considered their spaces stimulating. Figure 61 also suggests more respondents found their space to be "tense" than "relaxing".

Figure 62 indicates that few people considered the color of walls and partitions "excellent". Administrators considered wall color to be "good" or "fair", while analysts tended to consider theirs "fair" or "poor". Operators in Berlin and Kunia considered their colors "good" or "fair", while those in Augsburg considered theirs "poor" or "fair". Figure 63 confirms that respondents generally considered their facilities "drab" rather than "colorful", with Berlin and Kunia analysts, and Kunia operators particularly negative.





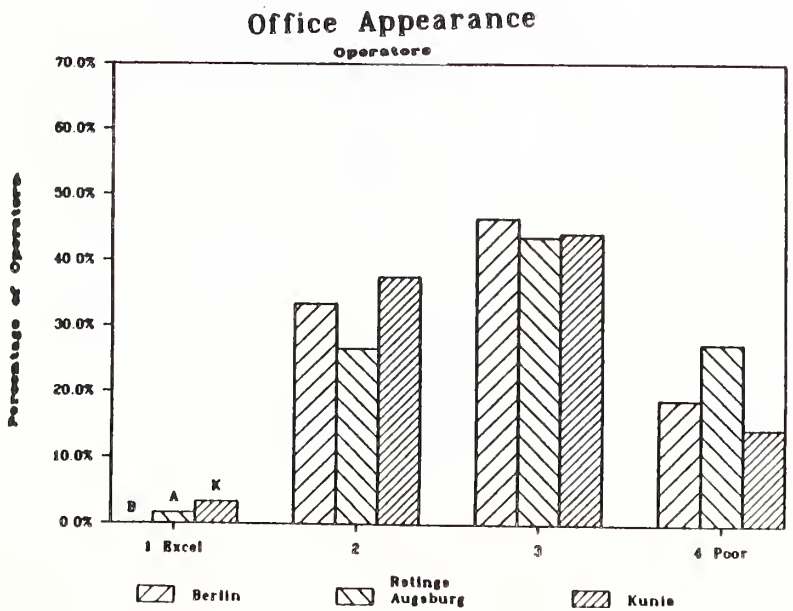
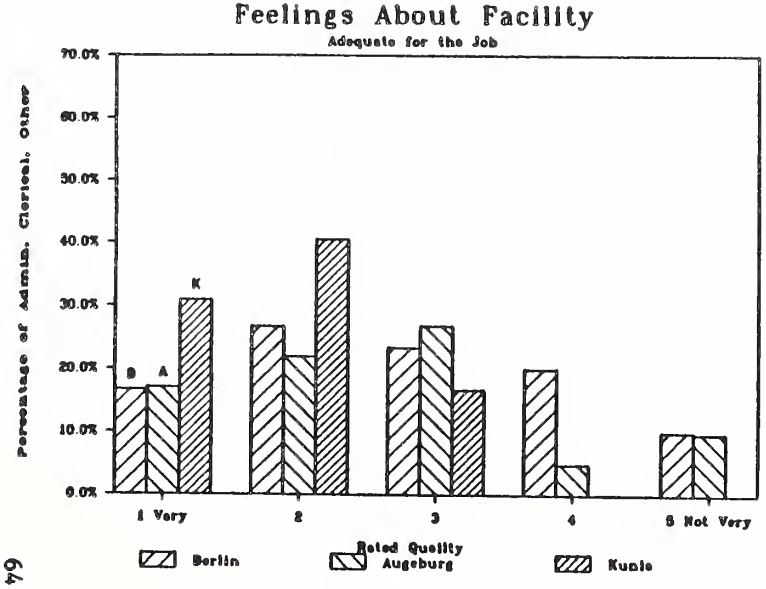
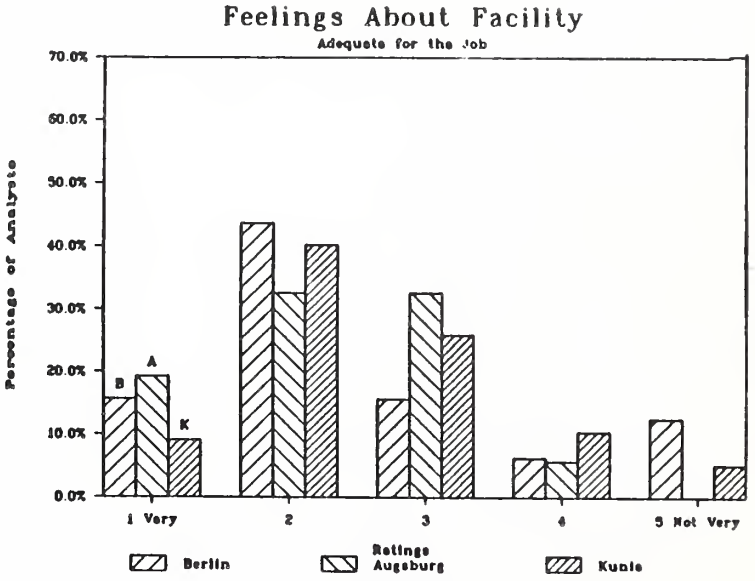


Figure 54. Percentage of People Rating the Way their Office Spaces Look





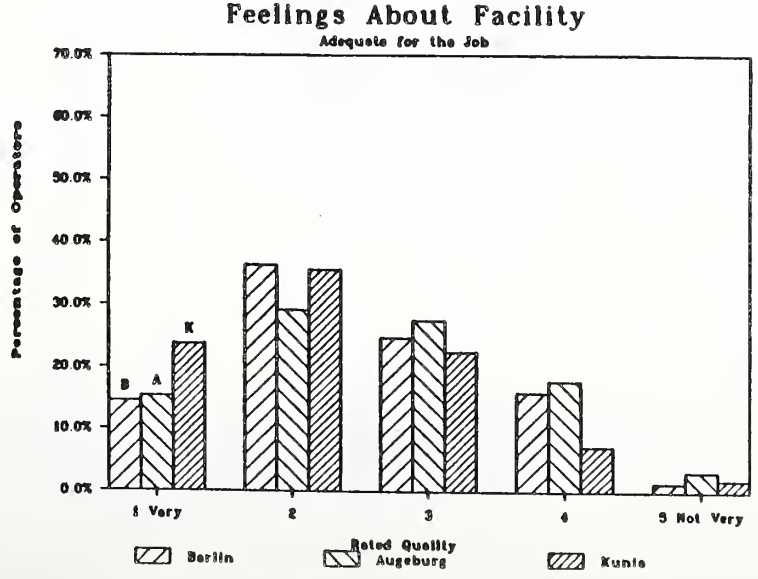
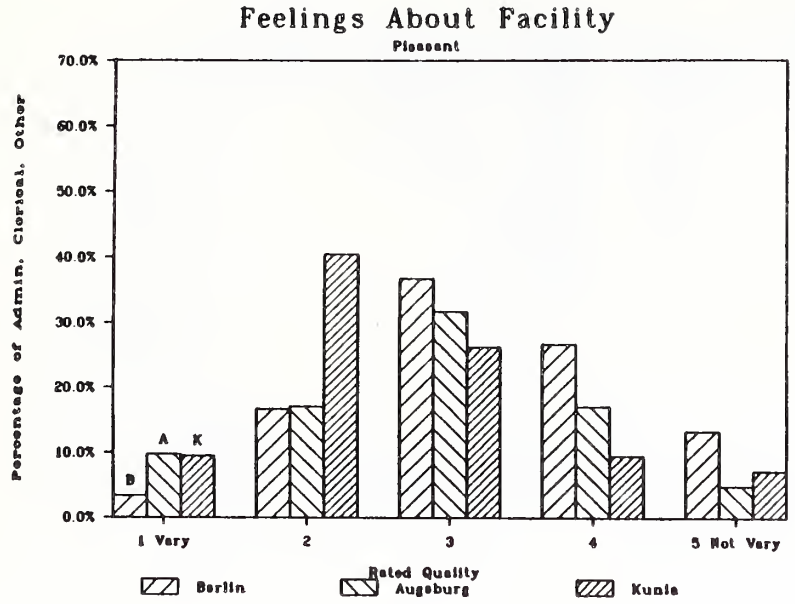
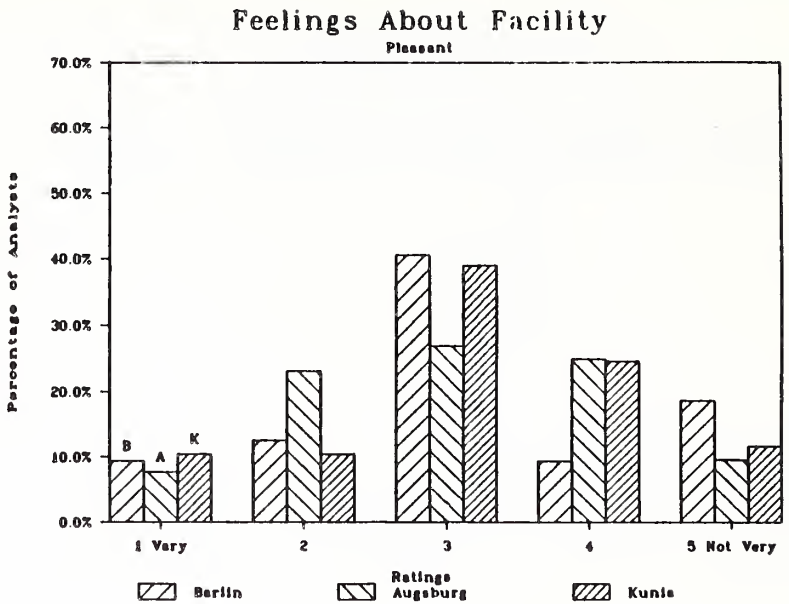


Figure 55. Percentage of People Indicating their Feelings about the Adequacy of the Facility of the Job they do.





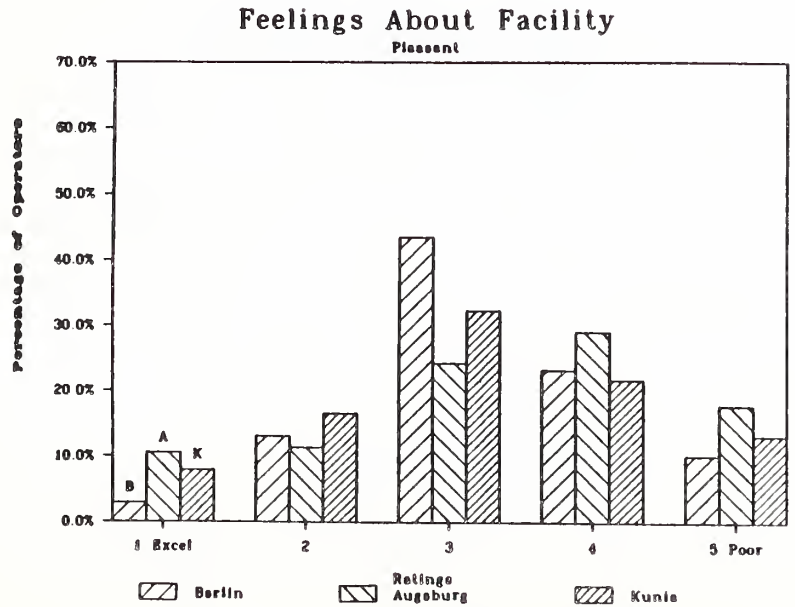
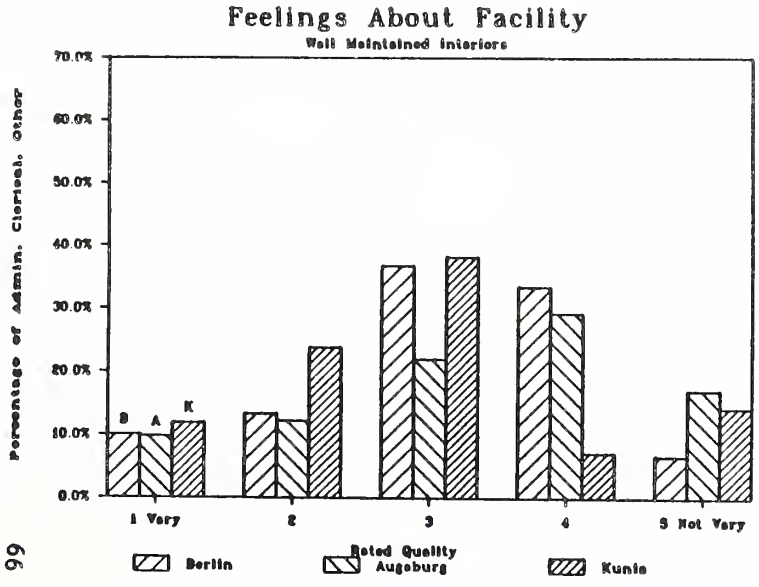
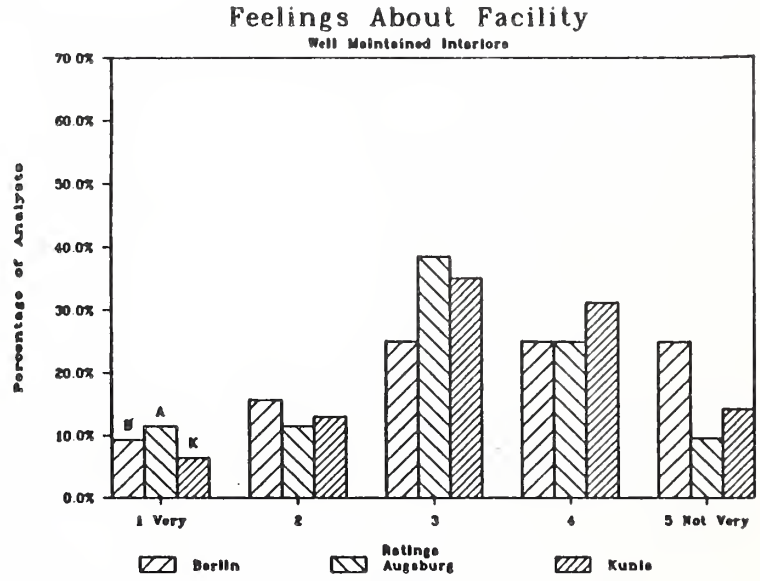


Figure 56. Percentage of People Indicating that they Feel their Facility is Pleasant





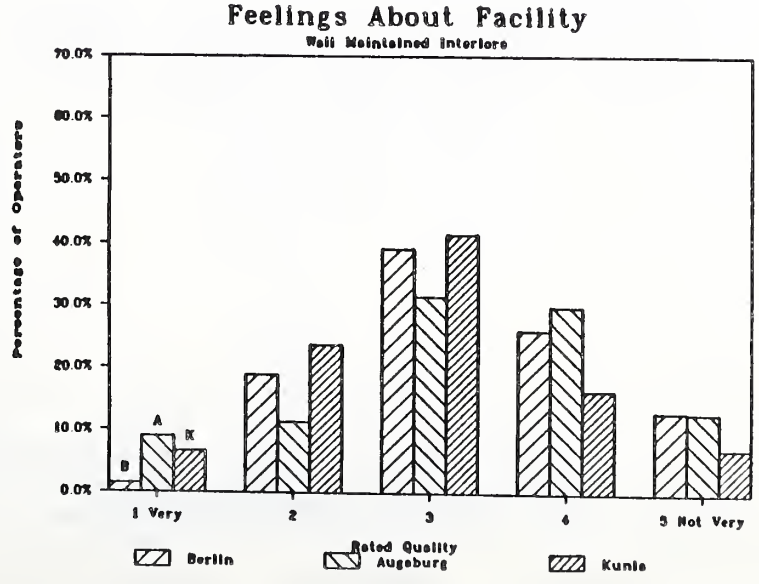
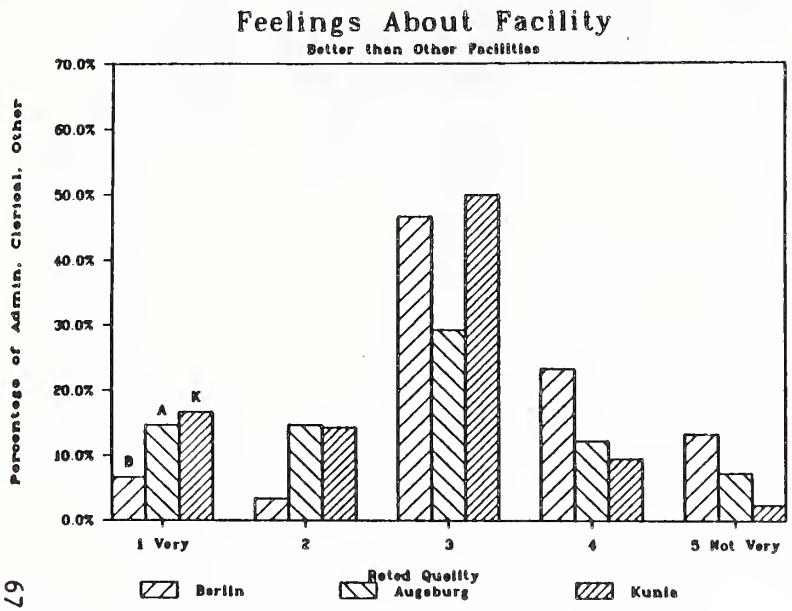
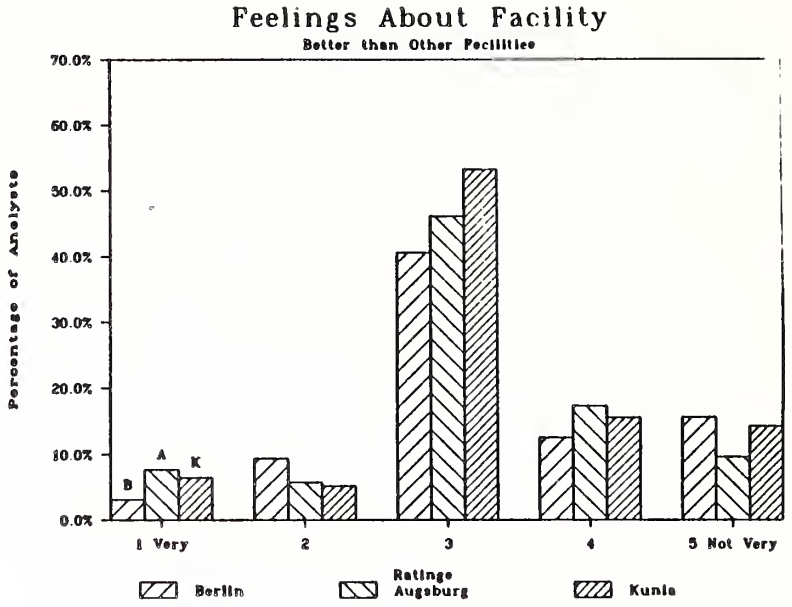


Figure 57. Percentage of People Indicating their Feelings about the Maintenance of the Facility





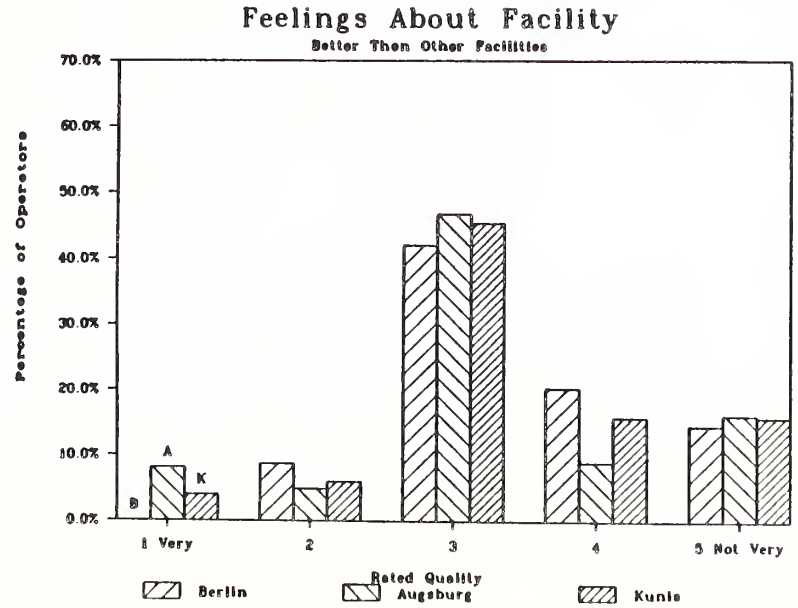
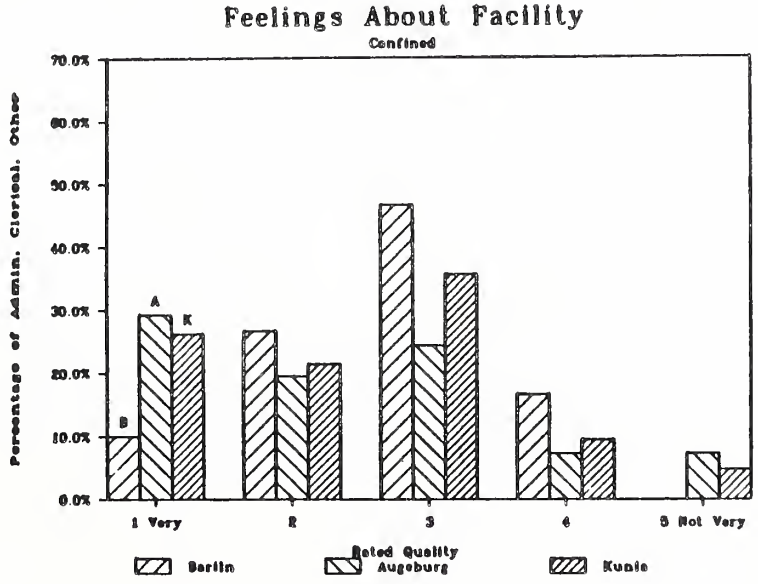
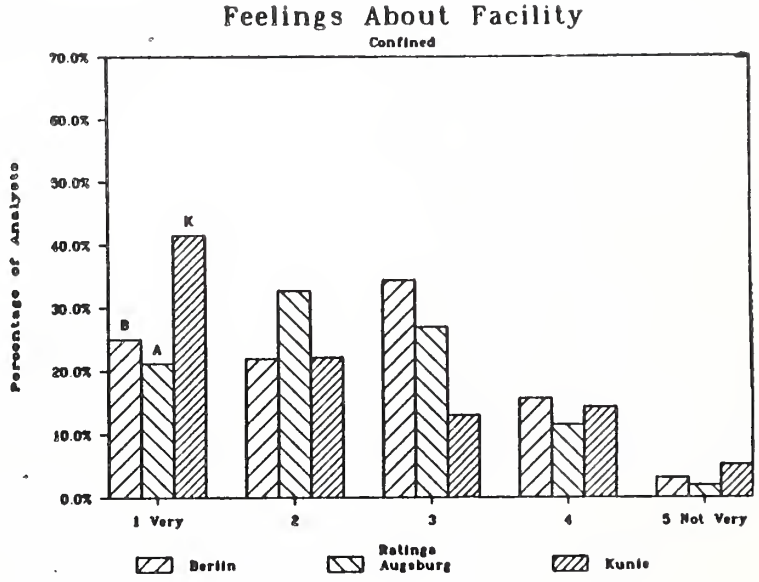


Figure 58. Percentage of People Indicating that they feel that their Facility is Better than Others





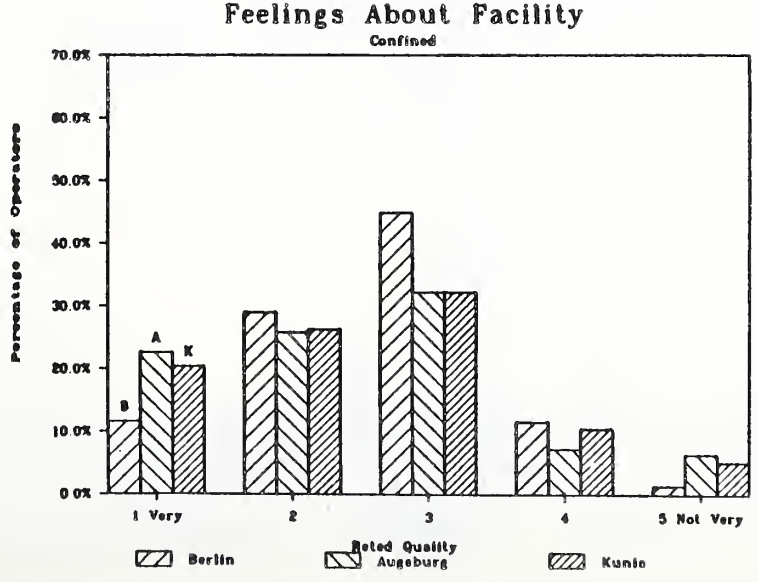
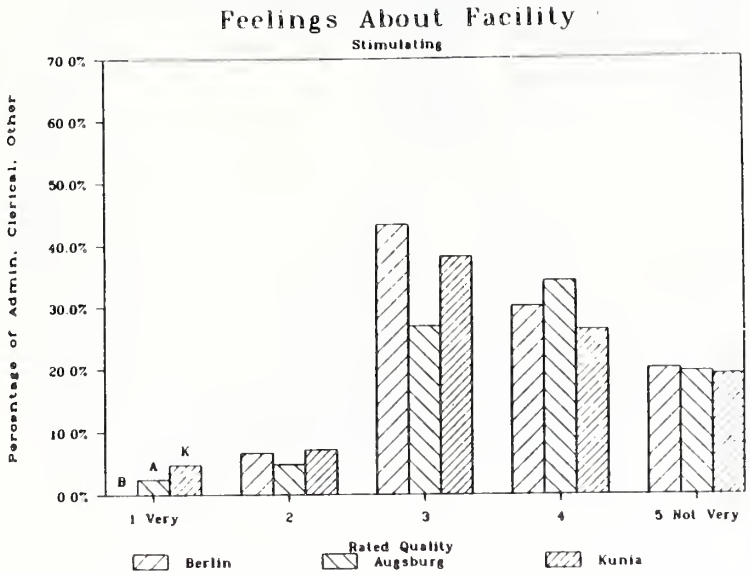
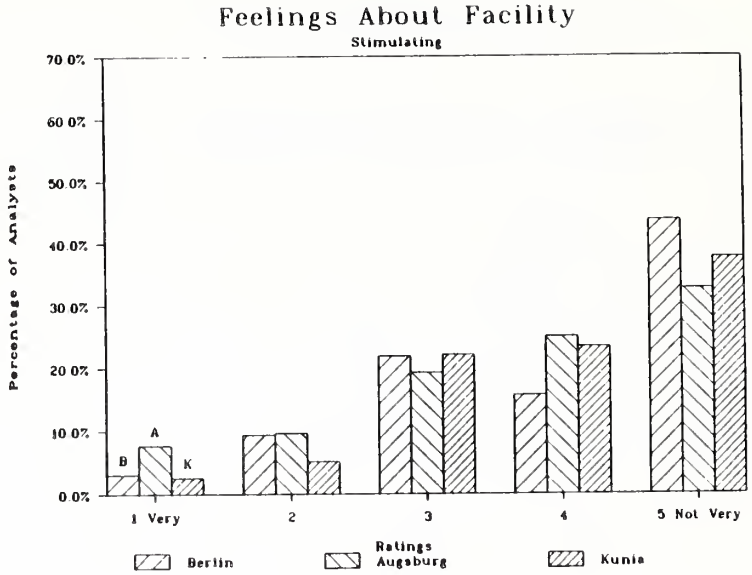


Figure 59. Percentage of People Indicating that they Feel Confined in their Facility





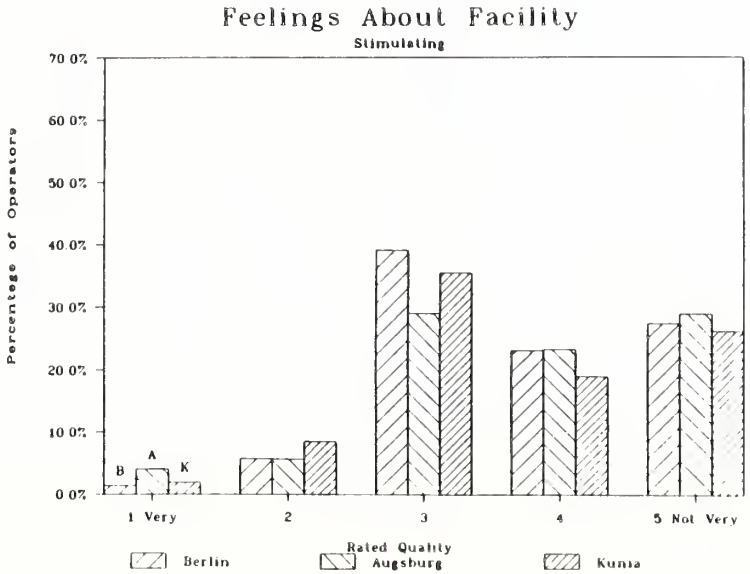
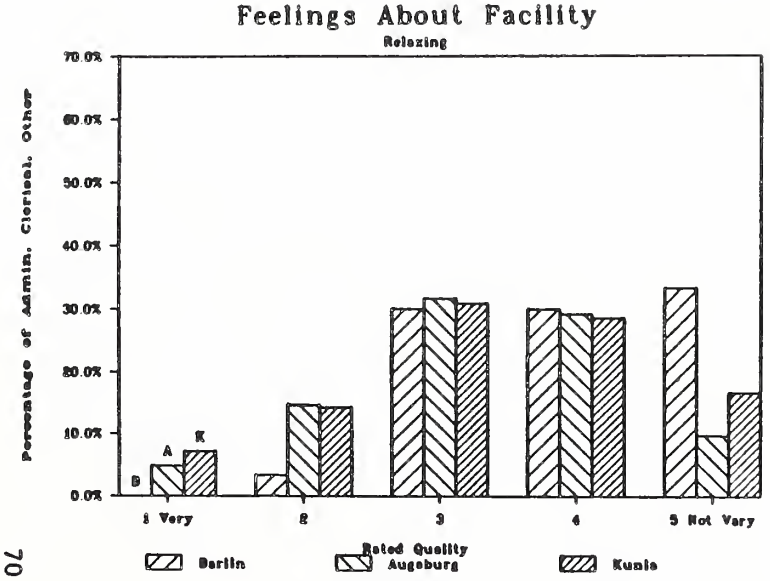
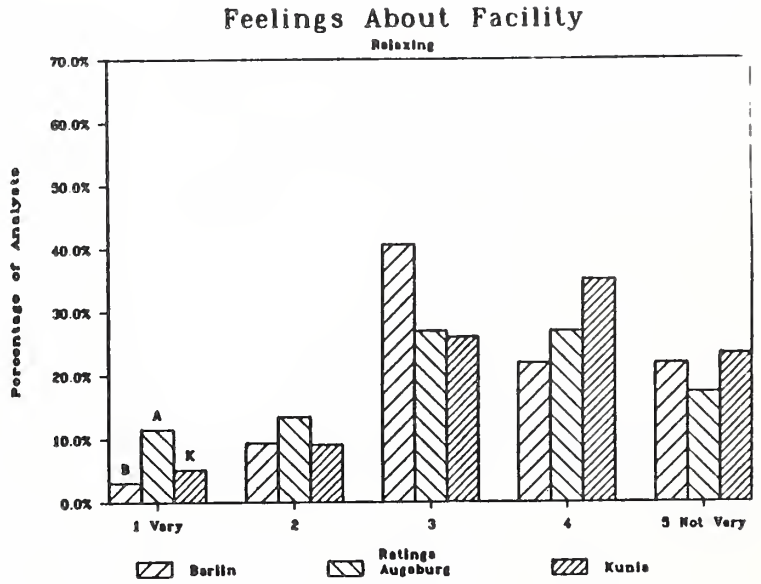


Figure 60. Percentage of People Indicating that they Feel their Facility is Stimulating





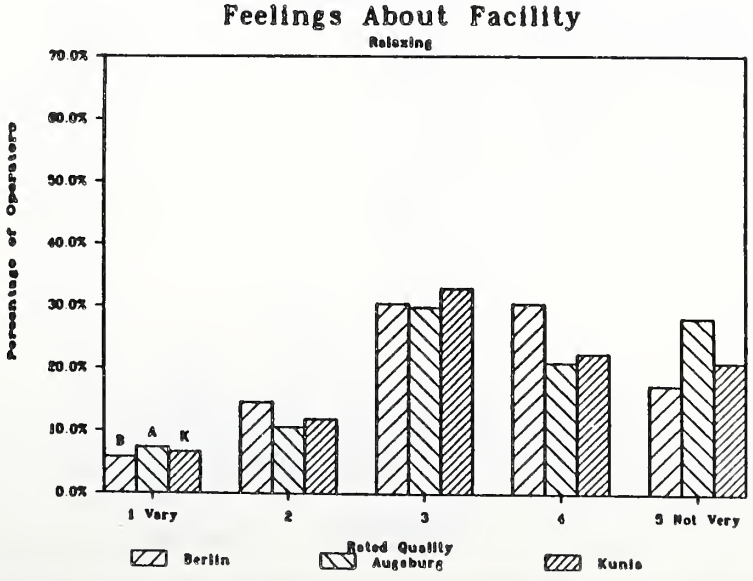
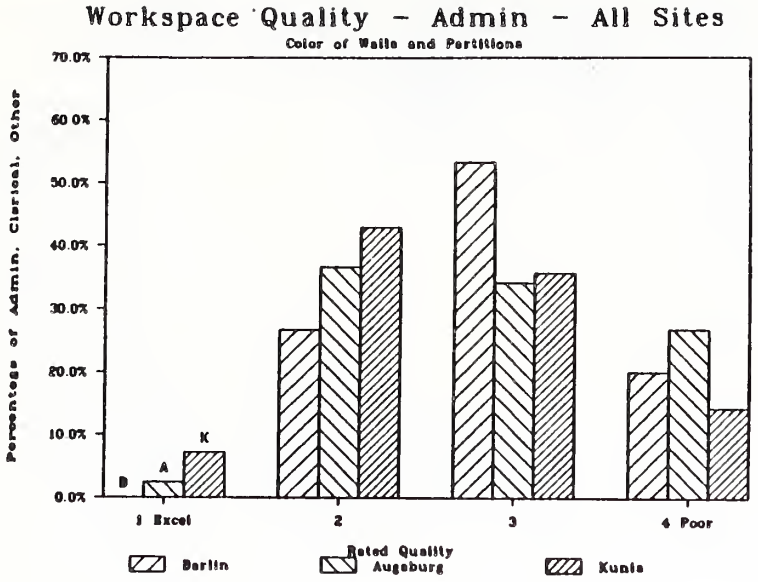
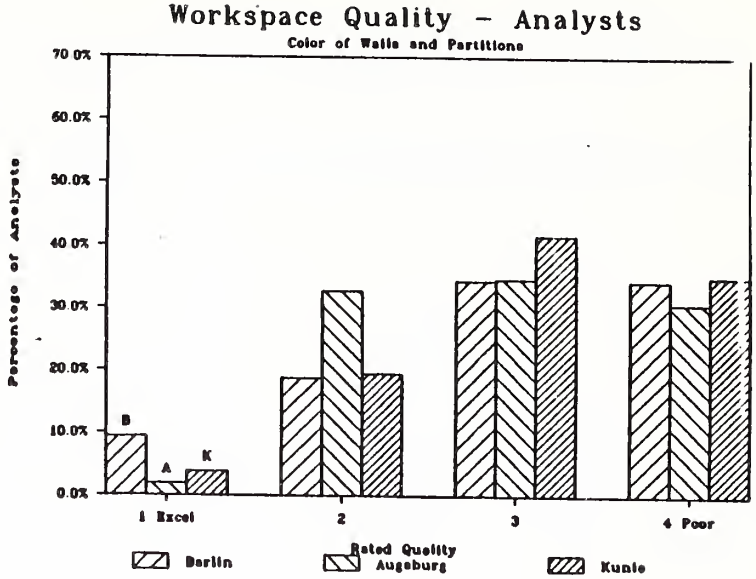


Figure 61. Percentage of People Indicating that they Feel their Facility is Relaxing





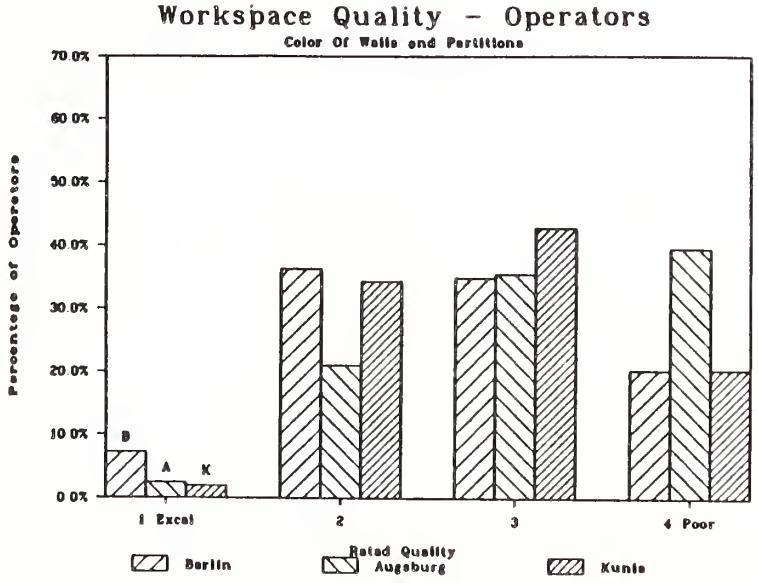
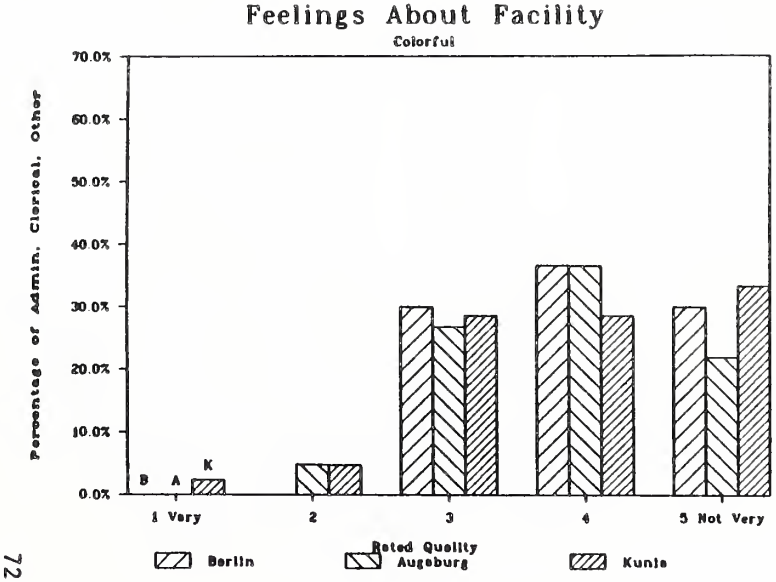
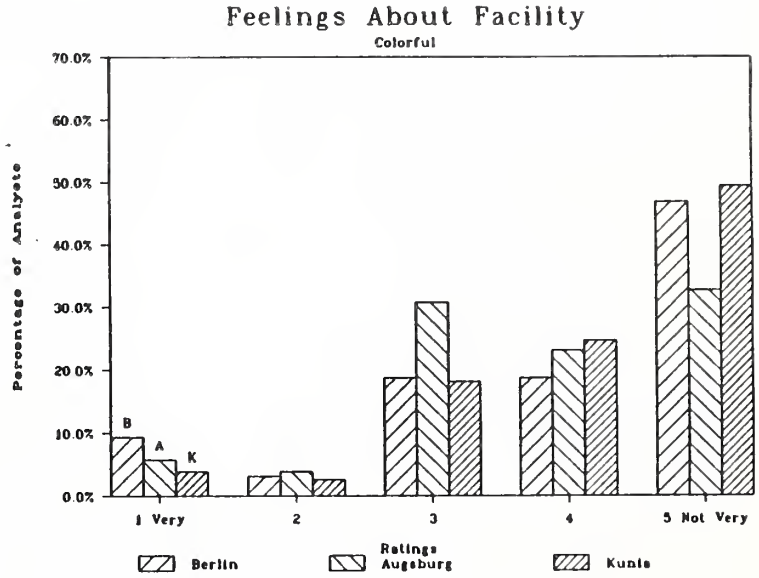


Figure 62. Percentage of People Rating the Color of the Walls and Partitions in their Workspace





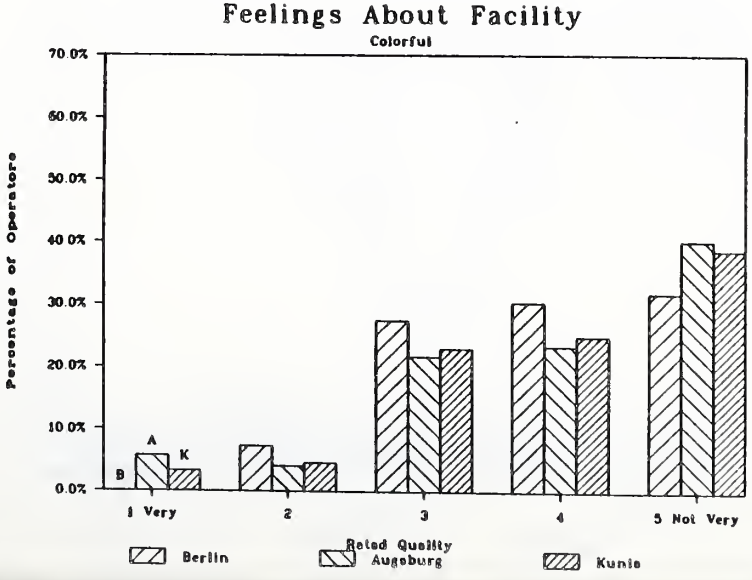
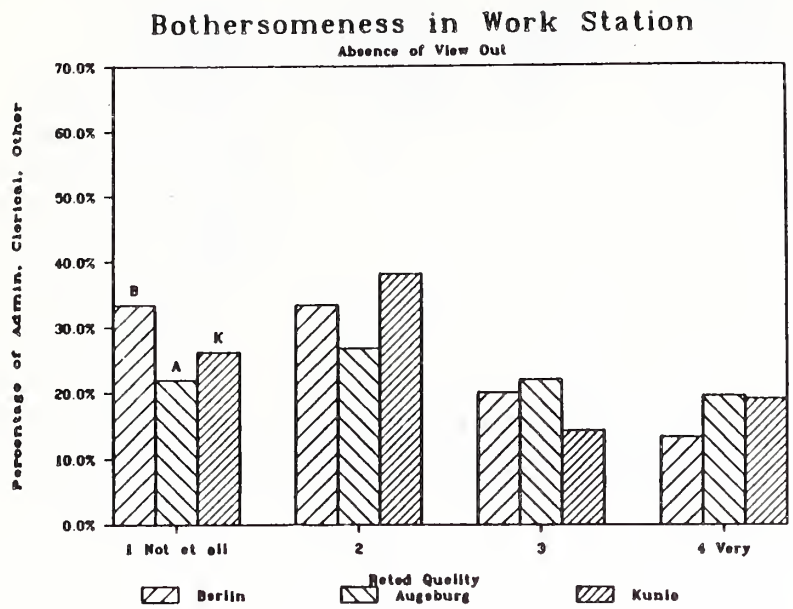
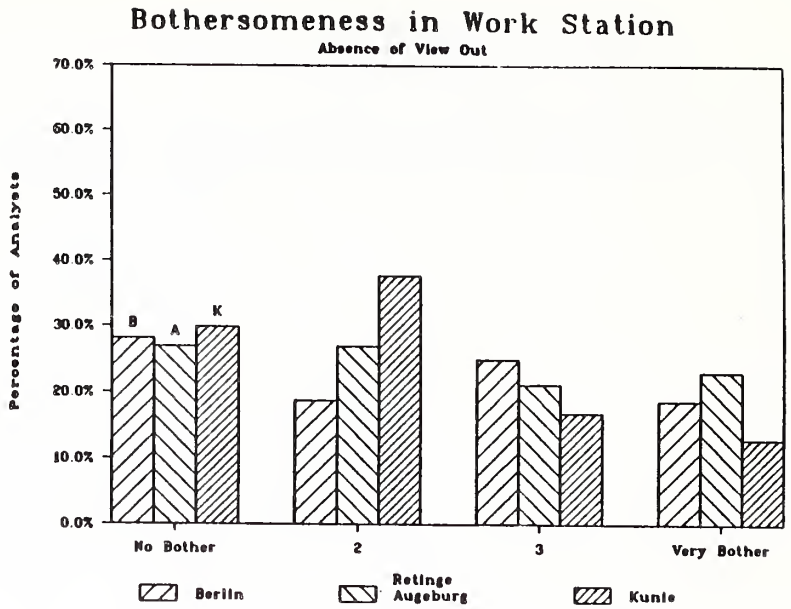


Figure 63. Percentage of People Rating the Overall Colorfulness of the Facility





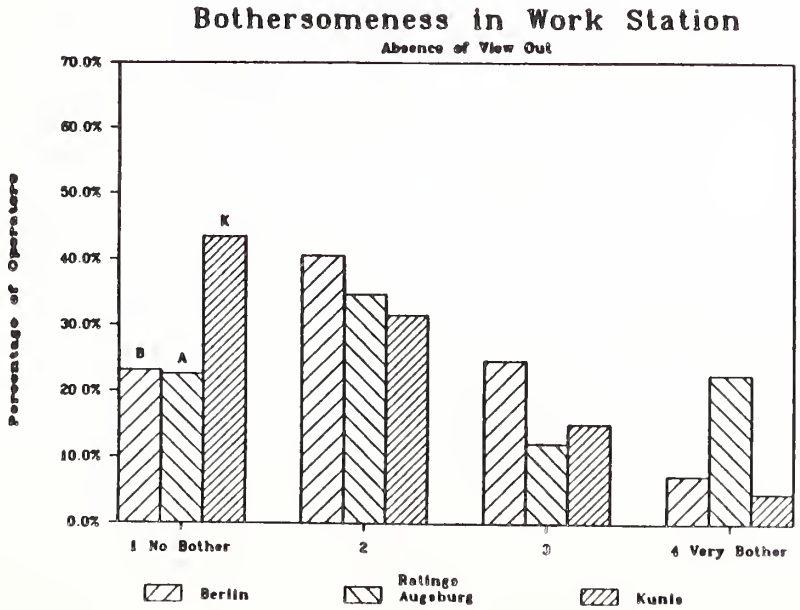
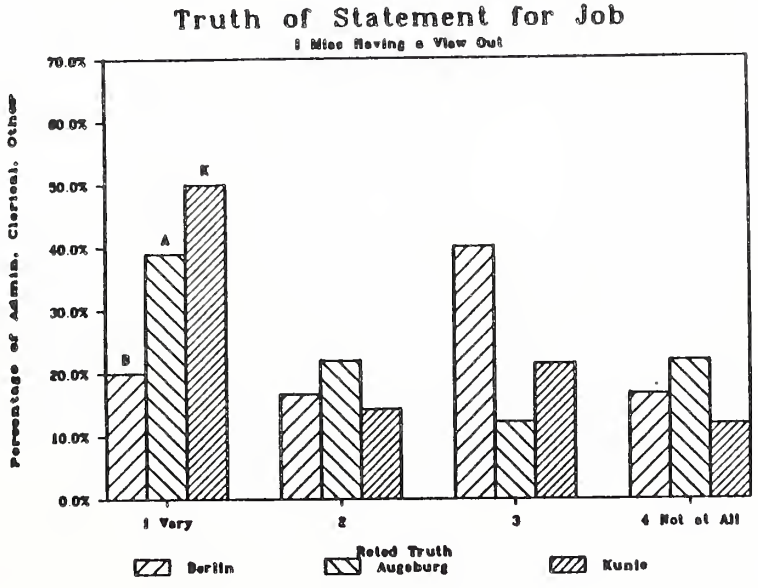
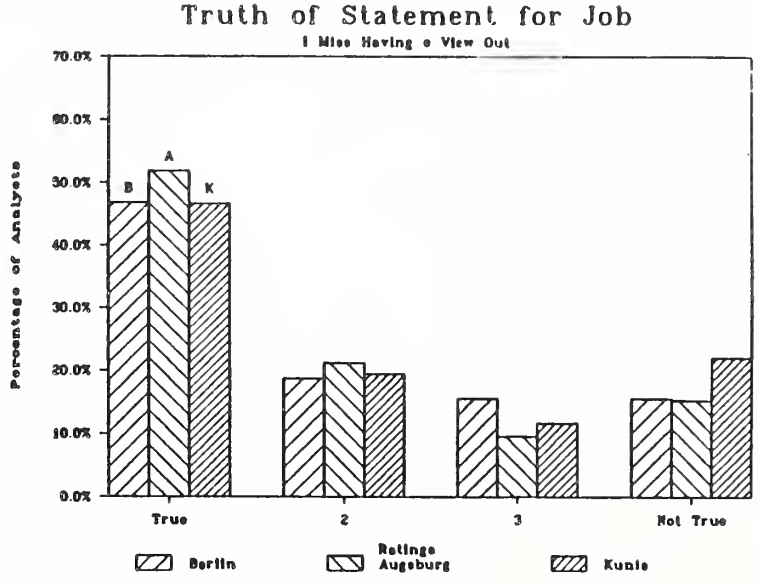


Figure 64. Percentage of People Indicating that the Absence of a View Out is Bothersome





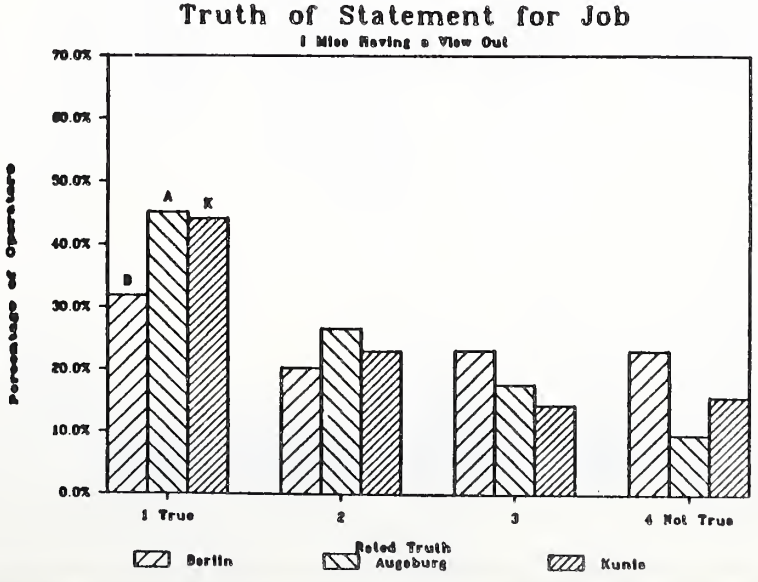
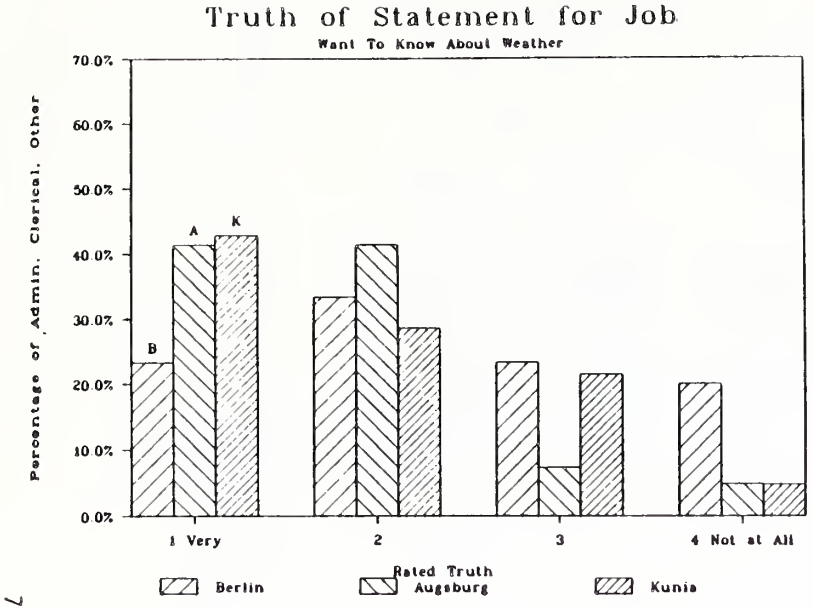
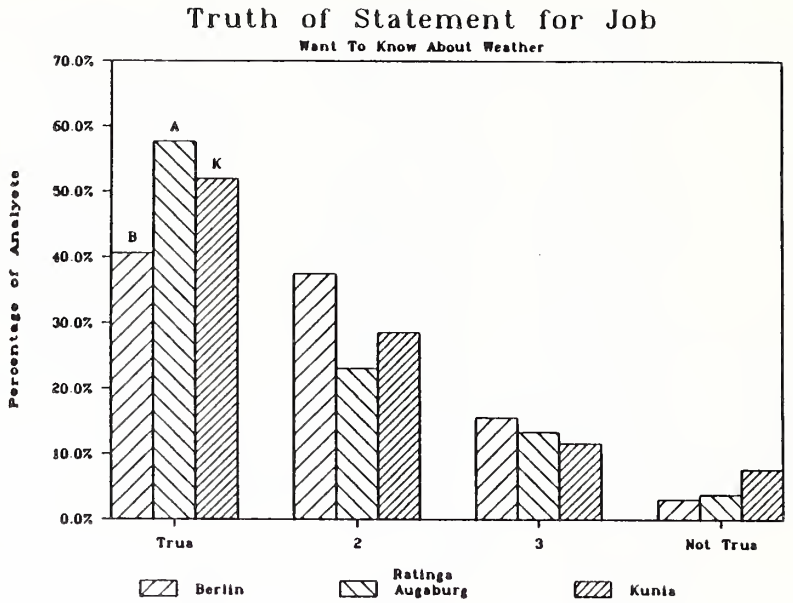


Figure 65. Percentage of People Indicating that they miss having a View Out in their Job





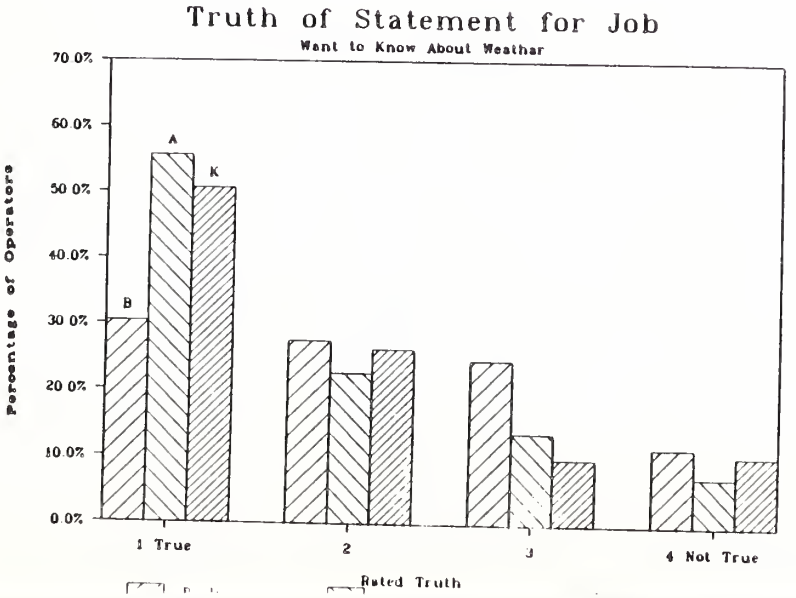


Figure 66. Percentage of People Indicating that they would like to know about the Weather

At the time that the physical measures were made, the experimenters noted the kinds and number of colors used in the workspaces. This assessment, given in section 5, reinforces the notion that the facilities tended to be drab, rather than colorful. Grey, white, black and brown tended to be the most frequently used colors for walls, furniture, and panels.

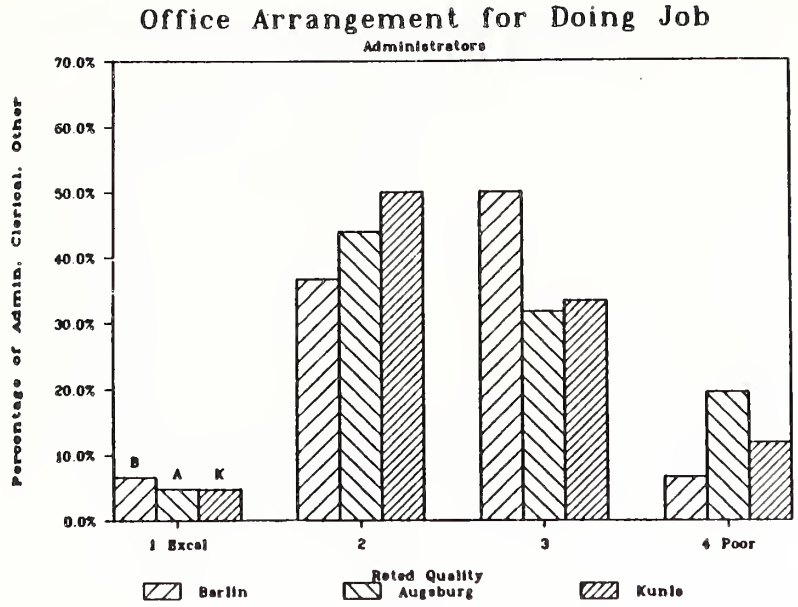
Figure 64 suggests that operators were not especially bothered by the absence of a view out, while there was no consensus among administrators and analysts on this question. Figure 65 indicates, however, that most respondents missed having a view out, with the only exception being administrators in Berlin. Finally, people especially those in Augsburg and Kunia expressed a desire to know about the weather outside, according to figure 66.

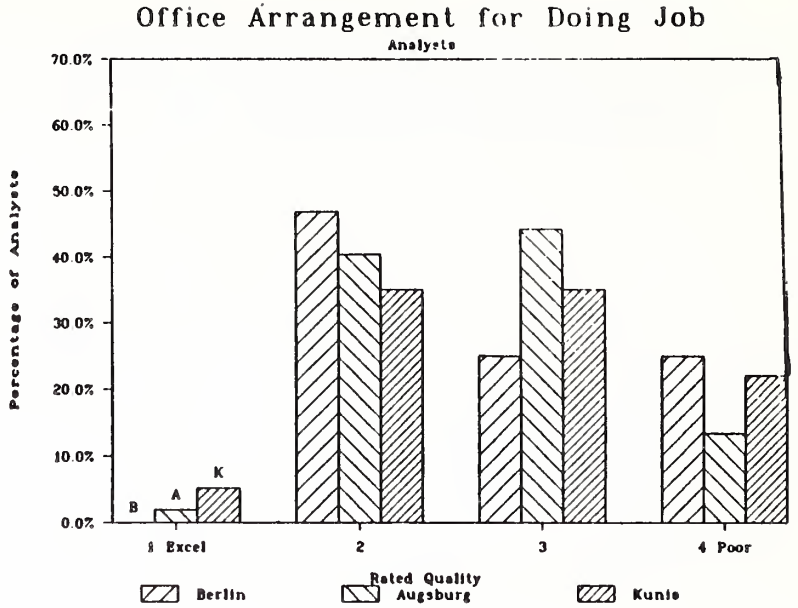
Figures 67 to 75 deal with perceptions of the available space. Figure 67 suggests that most respondents felt that their office arrangement was "good" or "fair", with those from Kunia rating their space as "good", and Berlin administrators and analysts and Augsburg operators rating their workspace as only "fair". Figure 68 indicates that about 90% of all respondents did not believe that people being "too far apart" was at all bothersome, while figure 69 suggests that about 30 to 40% of the sample felt that people being "too close together" was "somewhat" or "very bothersome". Another 30 to 40%, however, did not believe that was "at all bothersome". Figure 70 indicates that all respondents felt people "overhearing conversations" was a problem, with more than 80% of the analysts in Kunia finding this statement to be "very true".

Similarly, the majority of the respondents (figure 71) thought that their visual privacy was only "poor" or "fair". Figure 72 indicates mixed attitudes about the amount of available space. In general, administrators at Kunia and Berlin felt they had "good" or "excellent" amount of space, but those at Augsburg believed they only had a "fair" amount. Responses of analysts were evenly divided among "good", "fair", and "poor", with those at Berlin and Kunia tending more toward "poor". Operators rated the amount of space as "good" or "fair". Figure 73 indicates operators, analysts, and Berlin administrators believed the amount of space for personal items was "poor" or "fair". Only 5% believed it was "excellent". Figure 74 indicates Berlin analysts and Augsburg operators felt the amount of surface area for work was especially "poor", but more than 70% of all analysts and operators rated surface area as "fair" or "poor". Administrators at Kunia were somewhat more positive while those at Berlin were more negative. Figure 75 suggests that "lack of room to spread out paper tasks" was "very bothersome" to about 40% of the analysts in Berlin but less so to other groups. The other respondents rated the amount of room for paper tasks as "good" or "fair".

3.6 Response to the Condition of Furnishings

Figures 76 to 85 present data on the perception of furniture quality. Figure 76, which presents attitudes toward furniture quality in general, indicates that fewer than 5% of the analysts and operators considered their furniture to be excellent quality. Over 40% of Berlin analysts





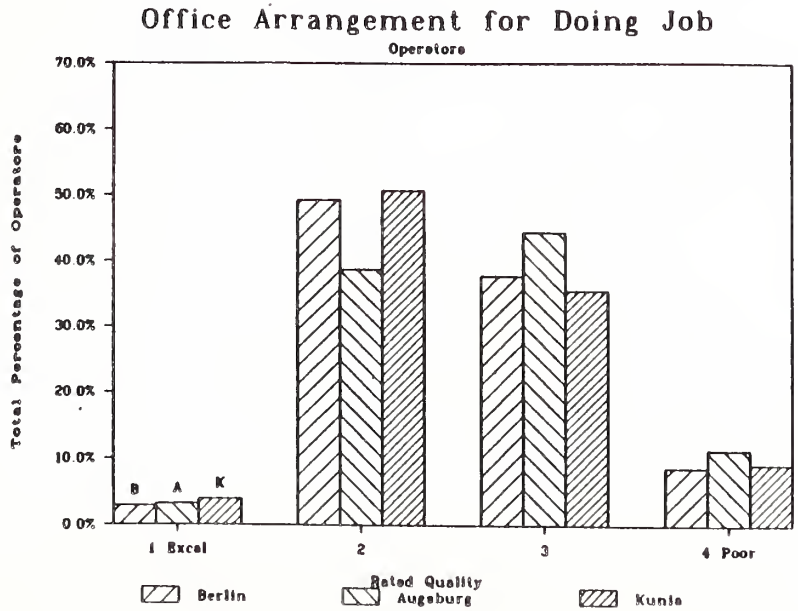
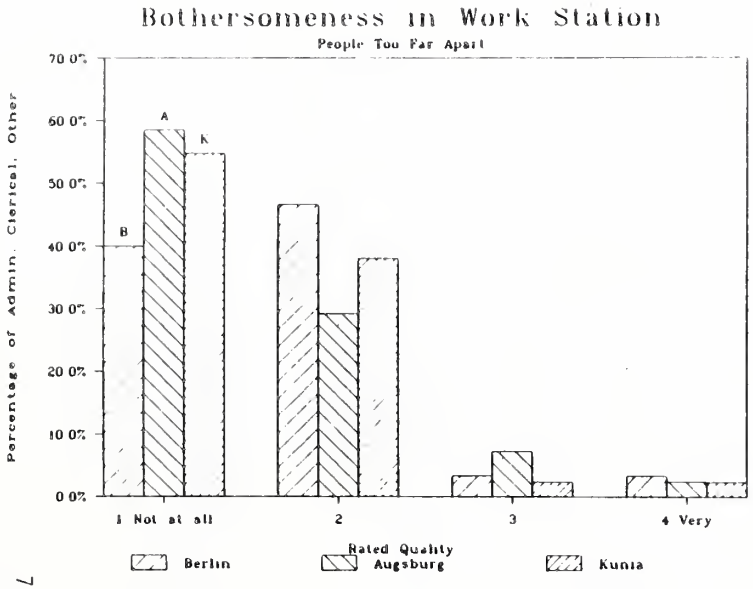
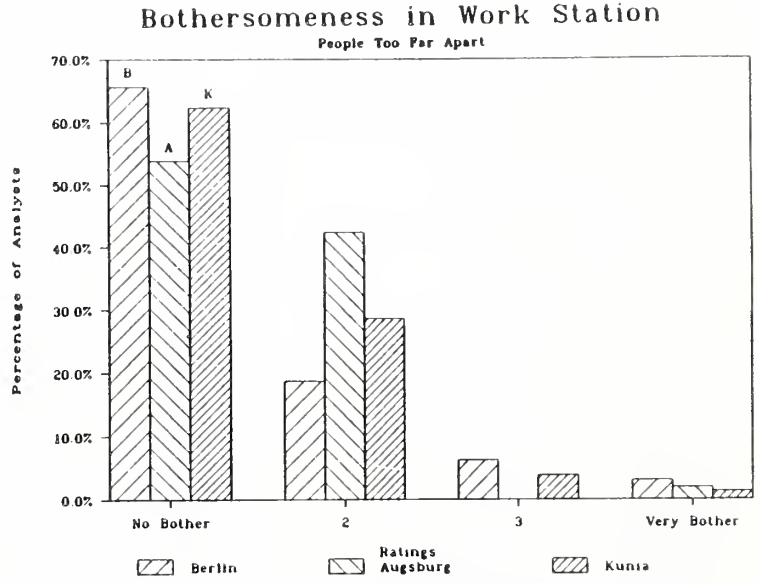


Figure 67. Percentage of People Rating the Effectiveness of the Office Arrangement for doing their Job





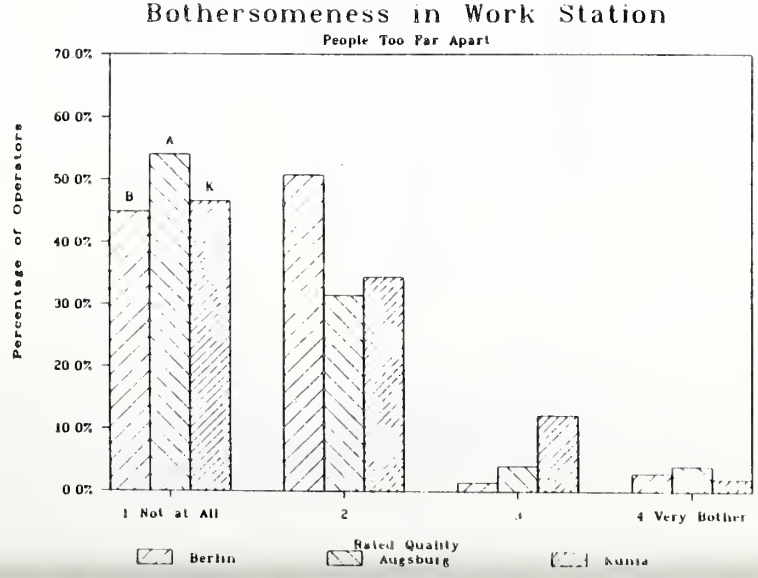
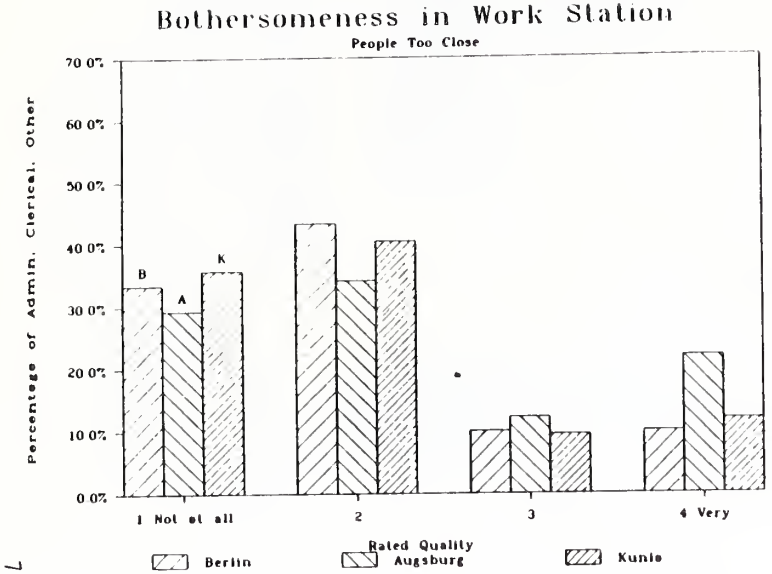
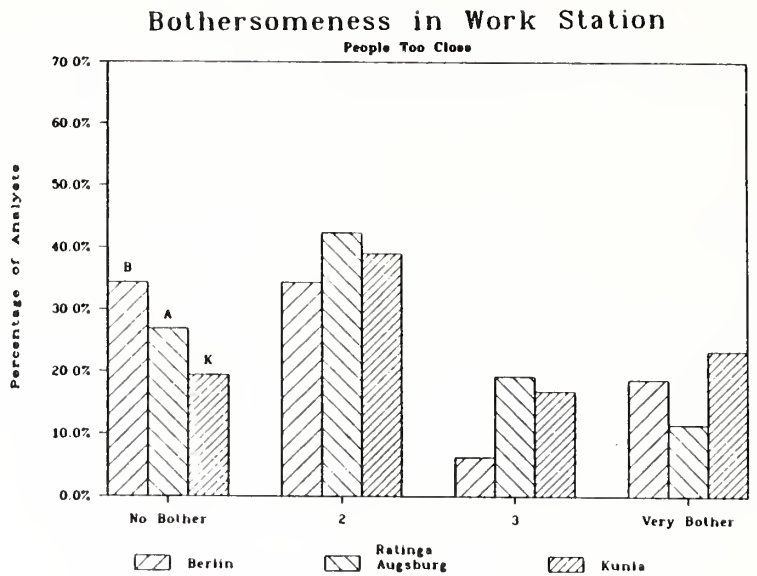


Figure 68. Percentage of People Indicating that People being too far Apart Bothersome





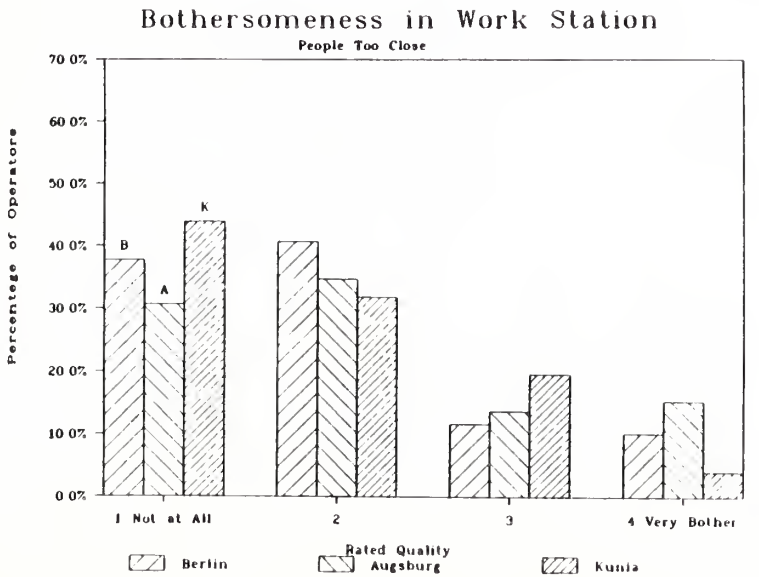
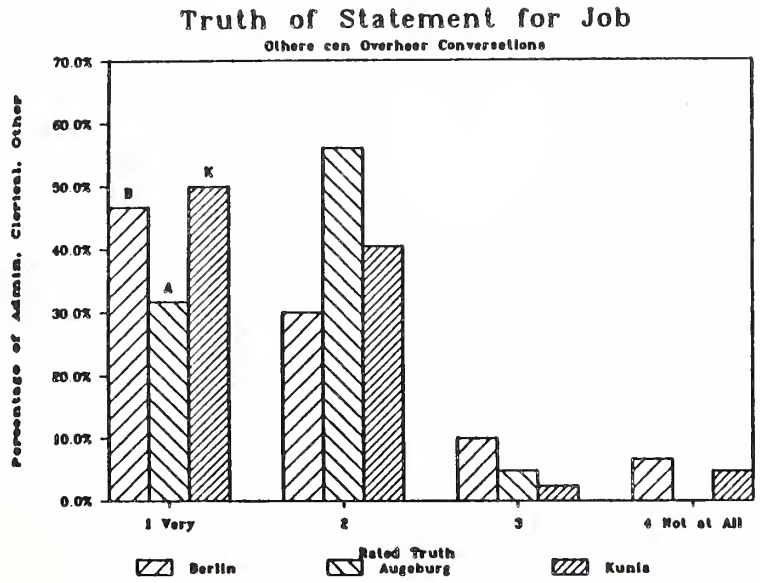
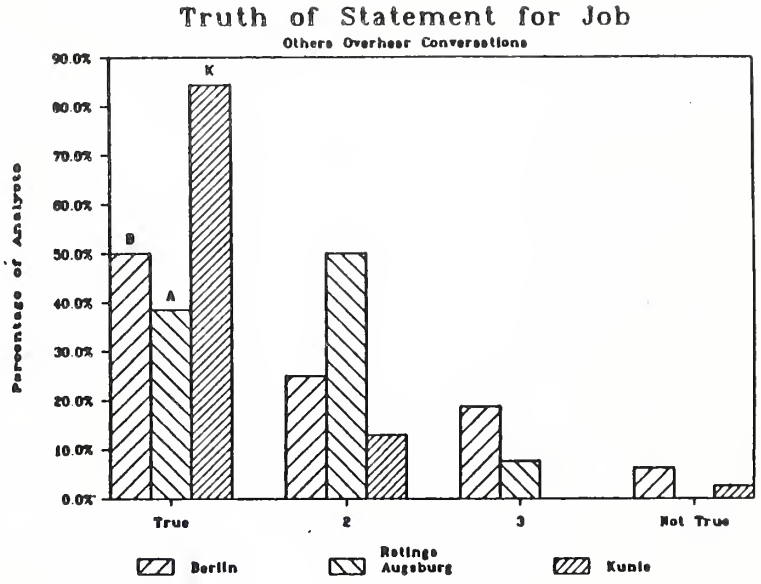


Figure 69. Percentage of People Indicating that Other People being to Close is Bothersome





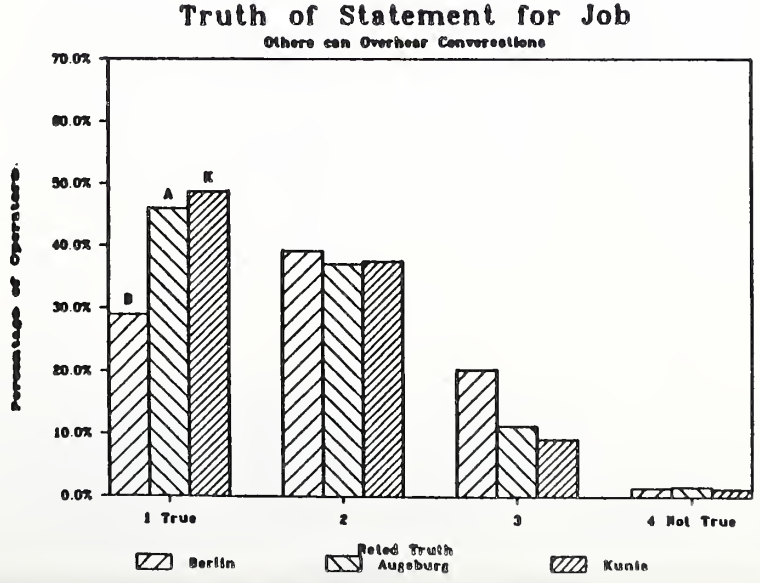
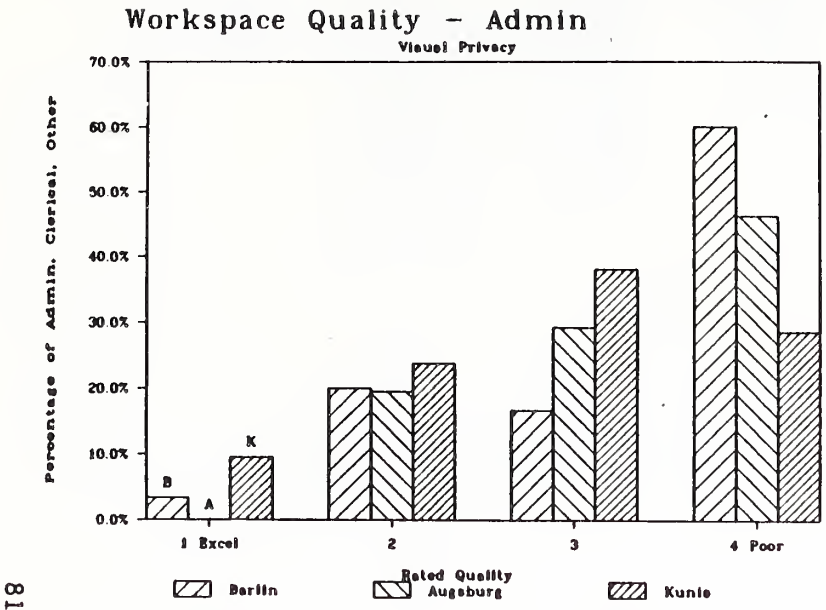
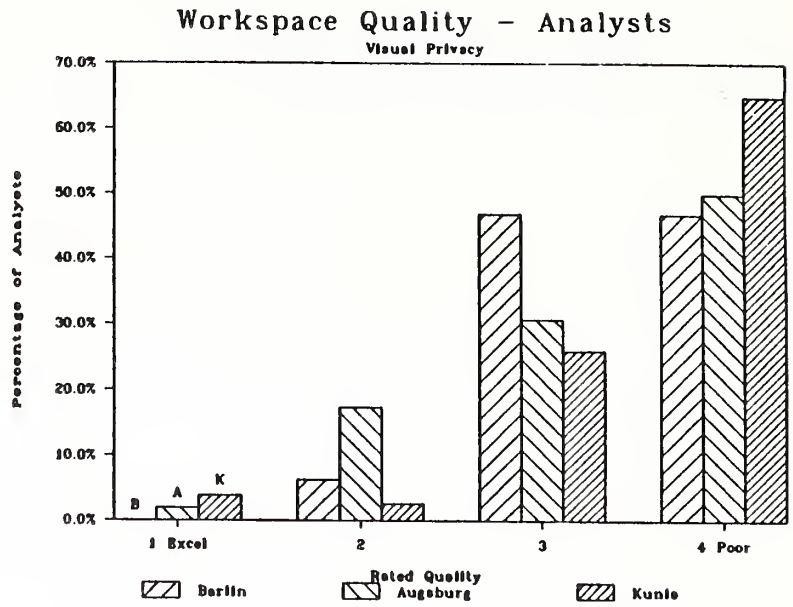


Figure 70. Percentage of People Indicating that Others Can Overhear their Conversation





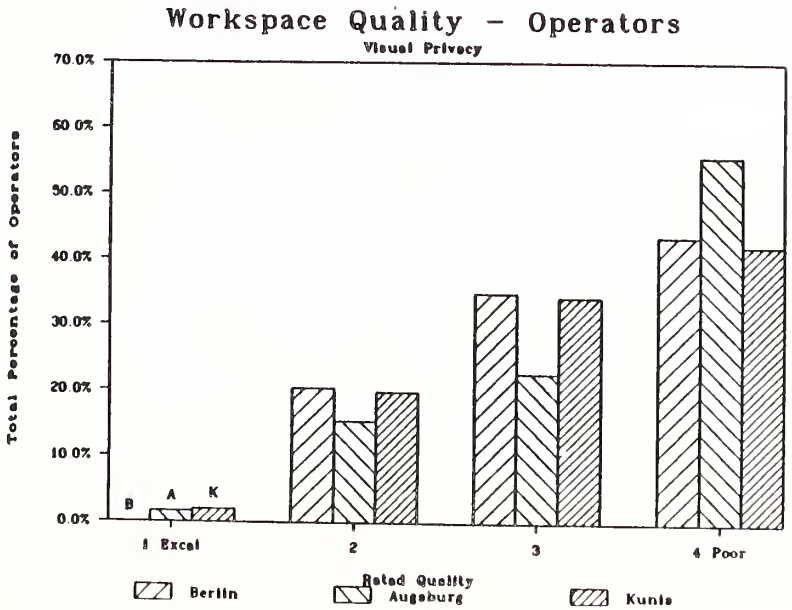
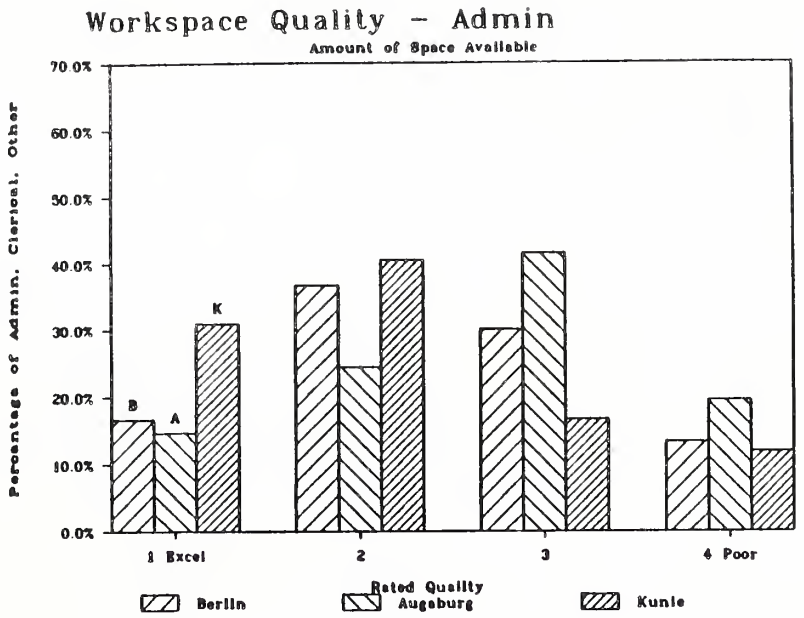
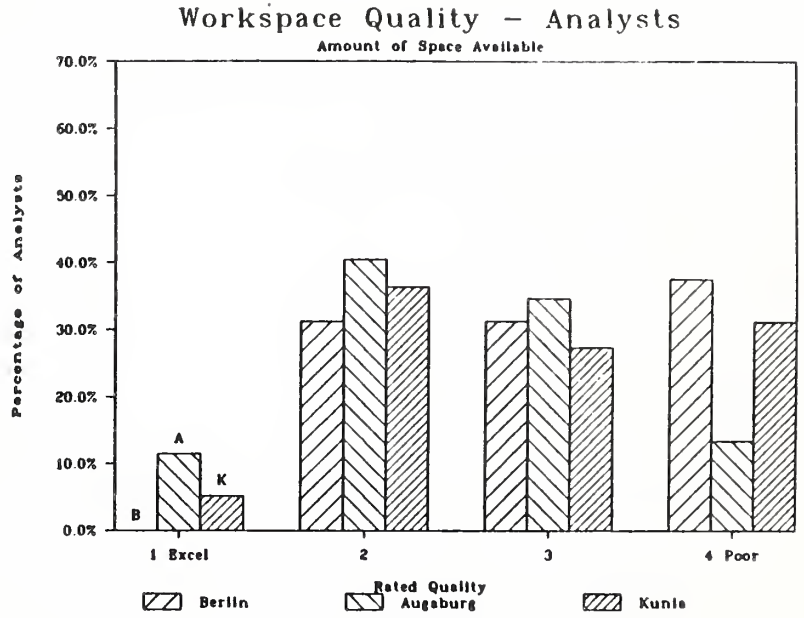


Figure 71. Percentage of People Rating the Amount of Visual Privacy at their Workspaces





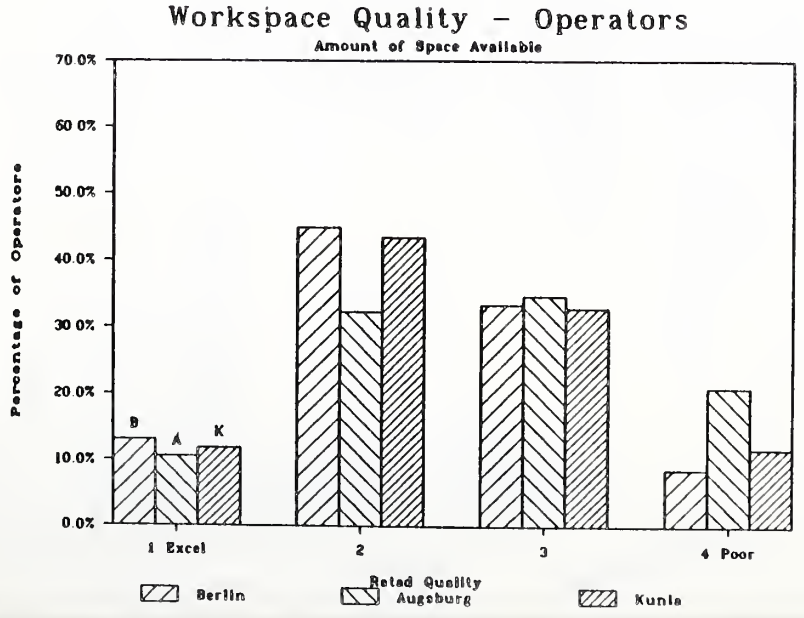
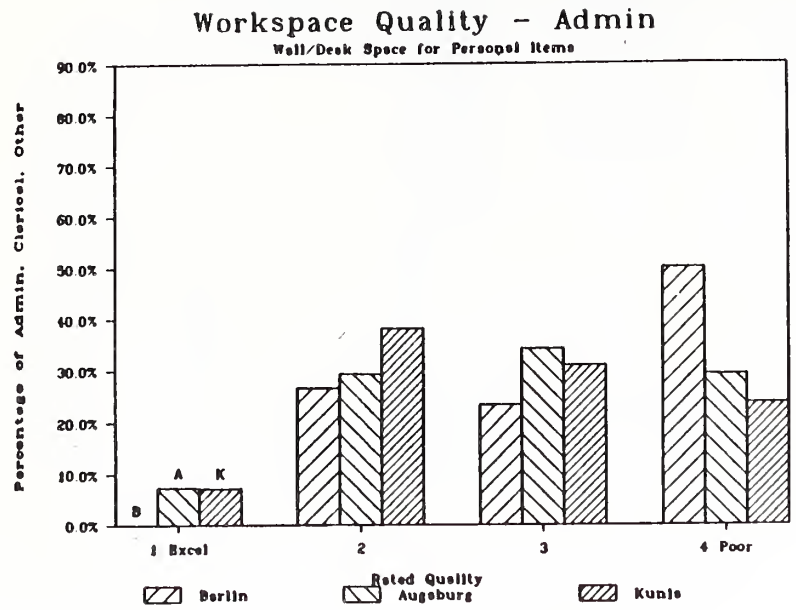
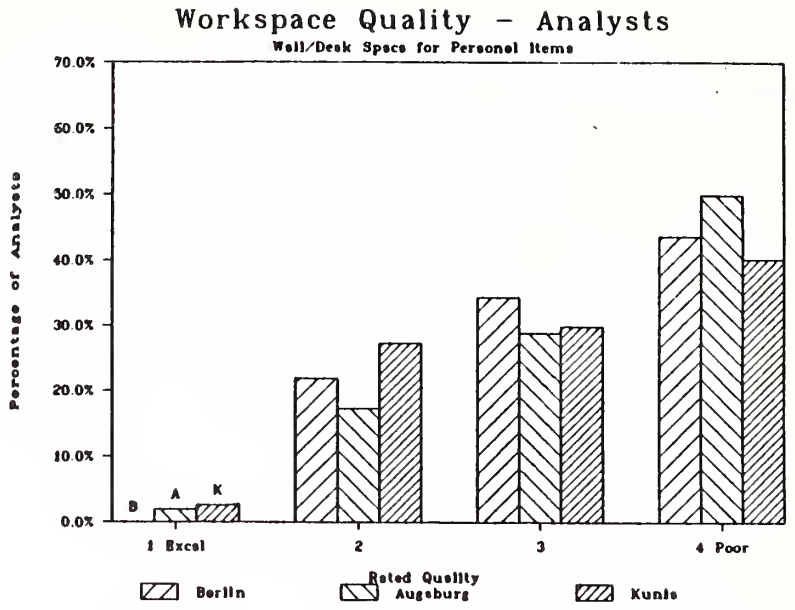


Figure 72. Percentage of People Rating the Amount of Space Available for Doing Work





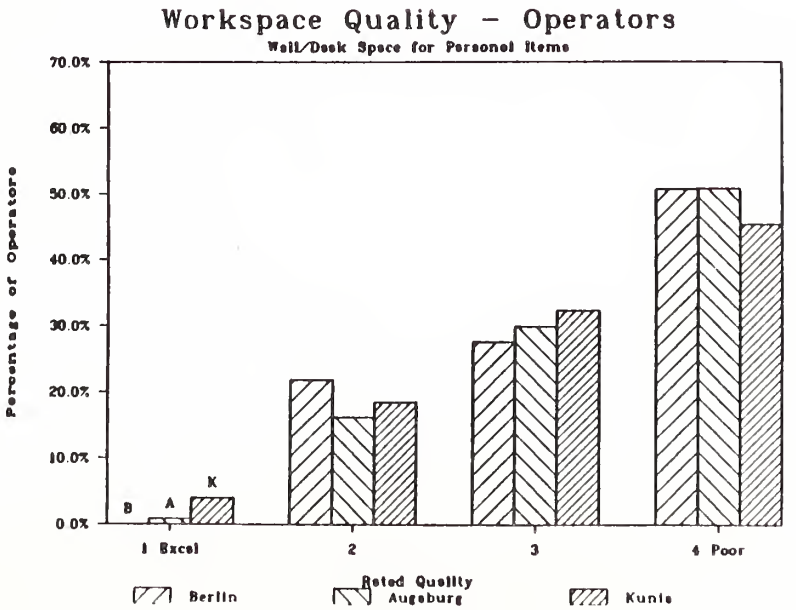
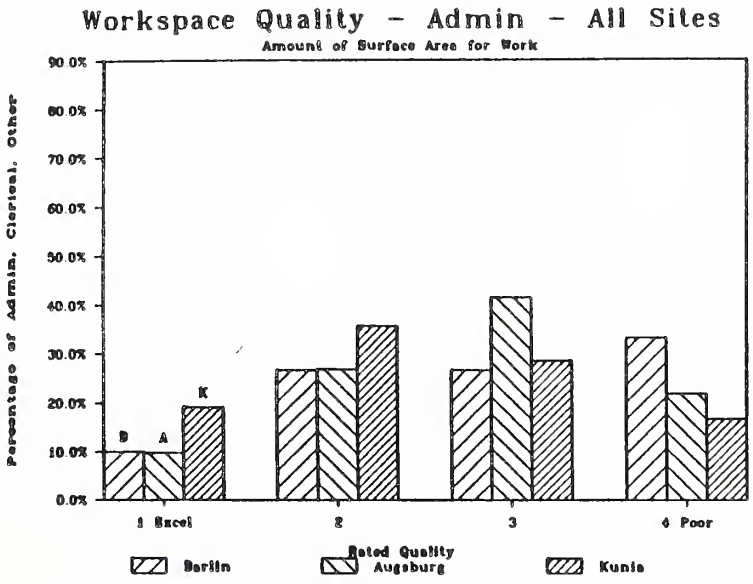
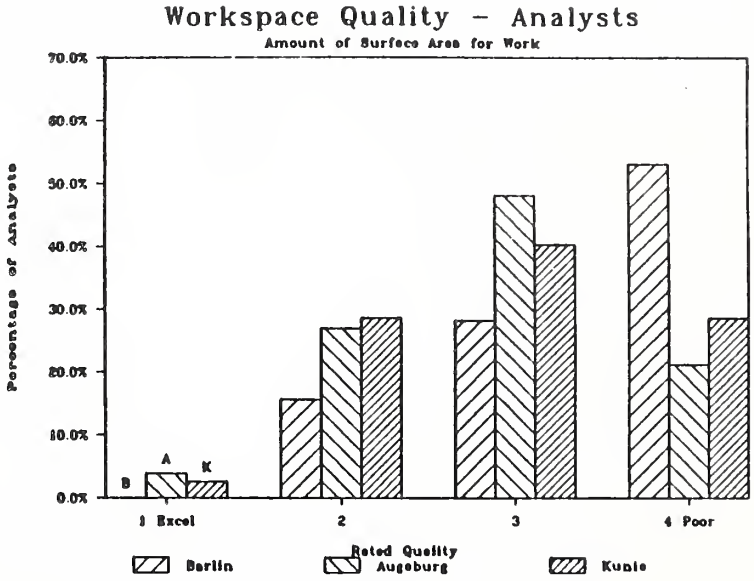


Figure 73. Percentage of People Rating the Amount of Wall and Desk Space Available for Personal Items





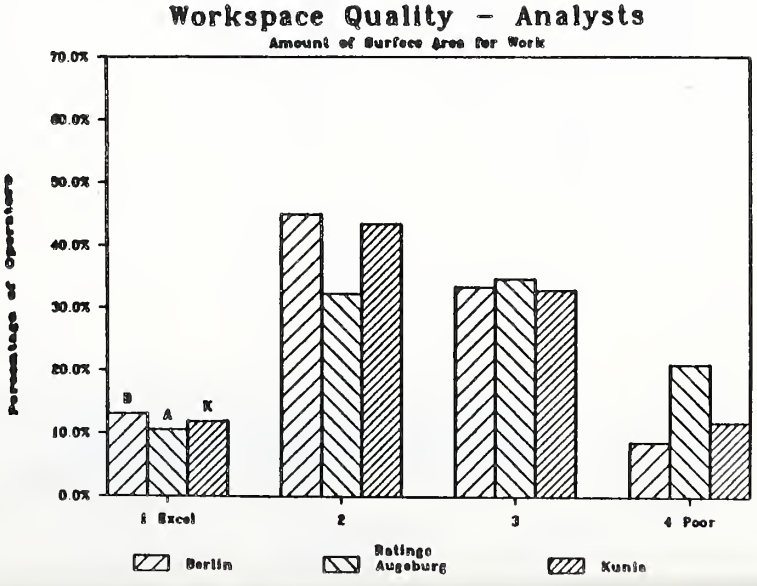
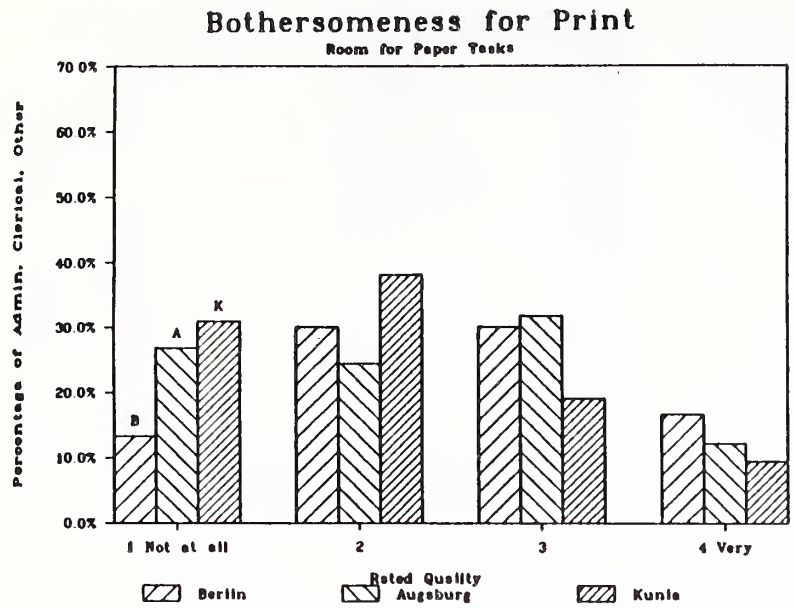
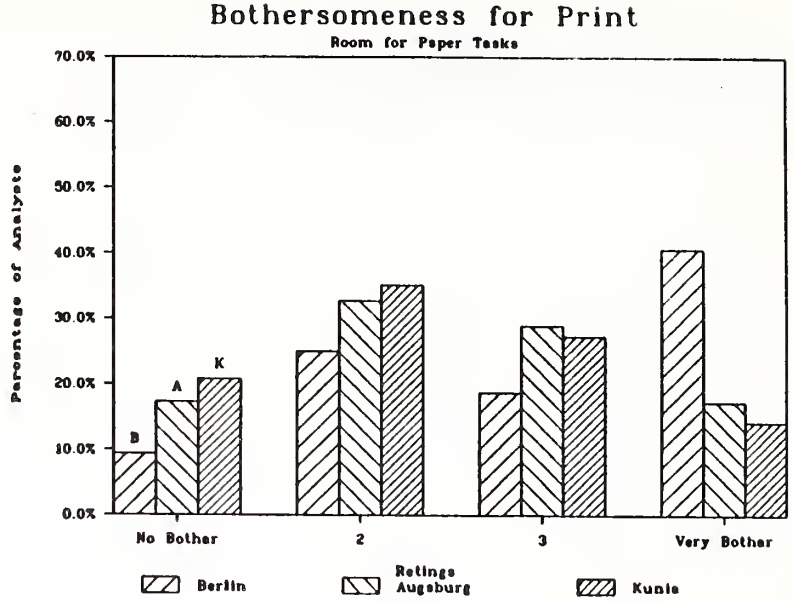


Figure 74. Percentage of People Rating the Amount of Surface Area in their Workspace for Doing Work





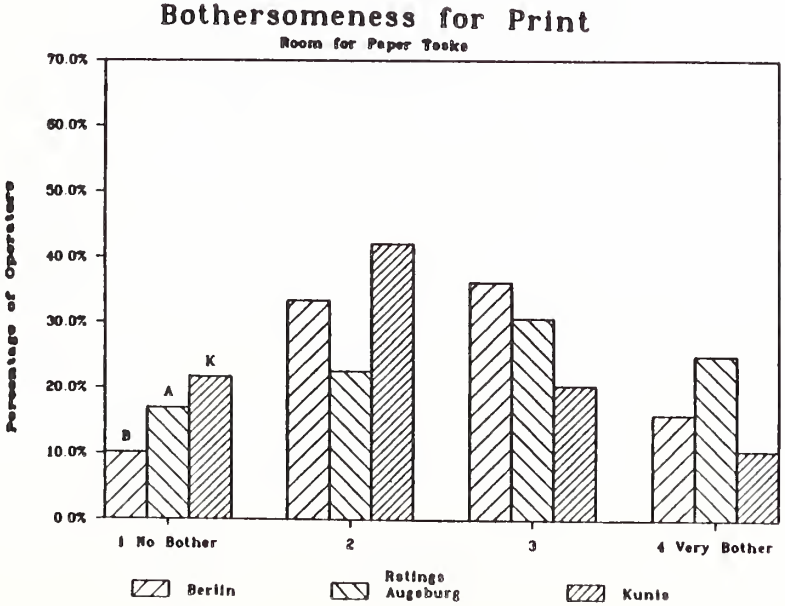
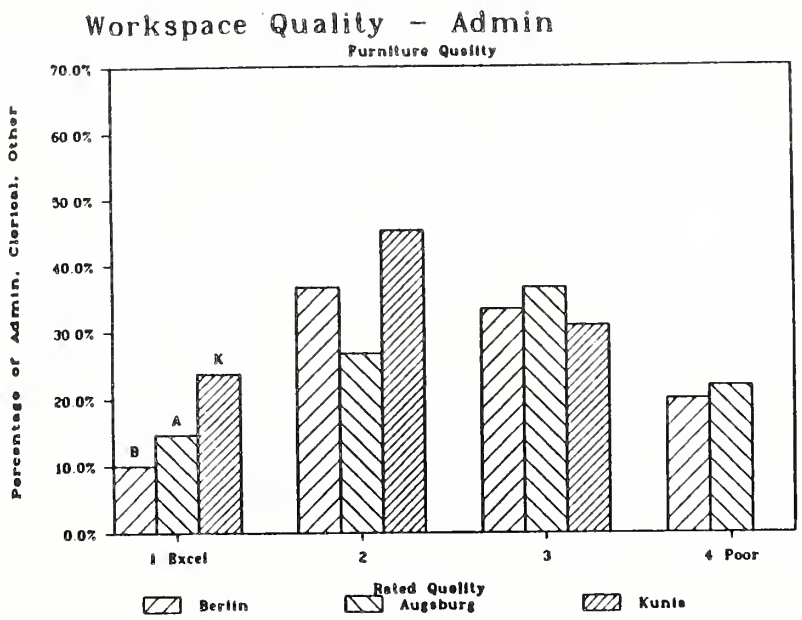
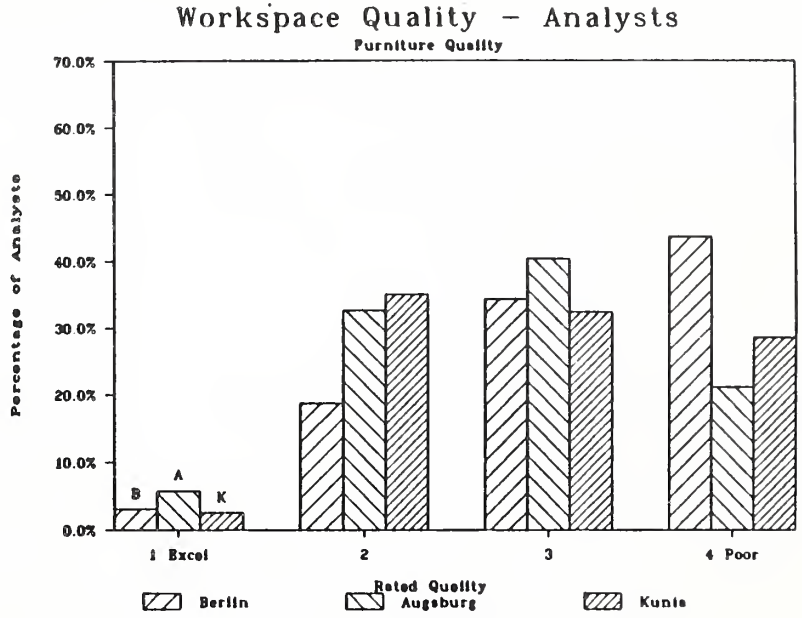


Figure 75. Percentage of People Rating the Bothersomeness of the Amount of Room for Paper Tasks





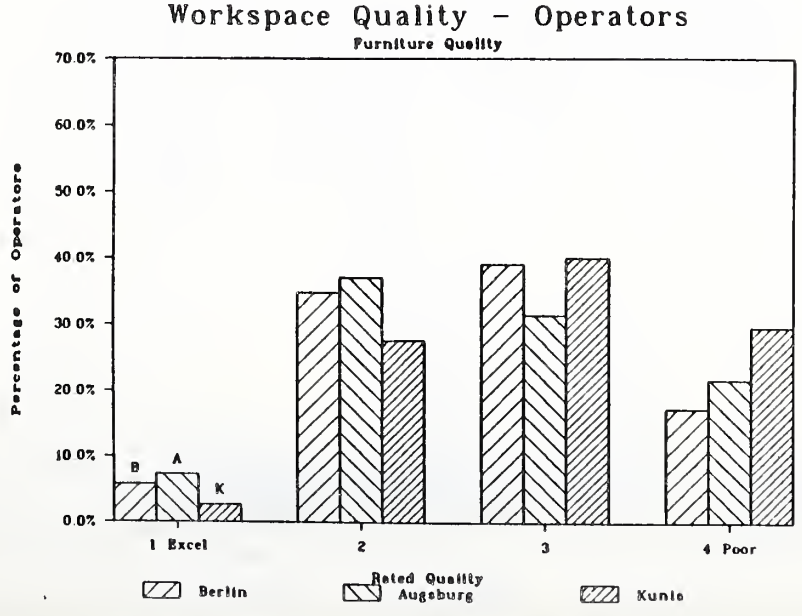
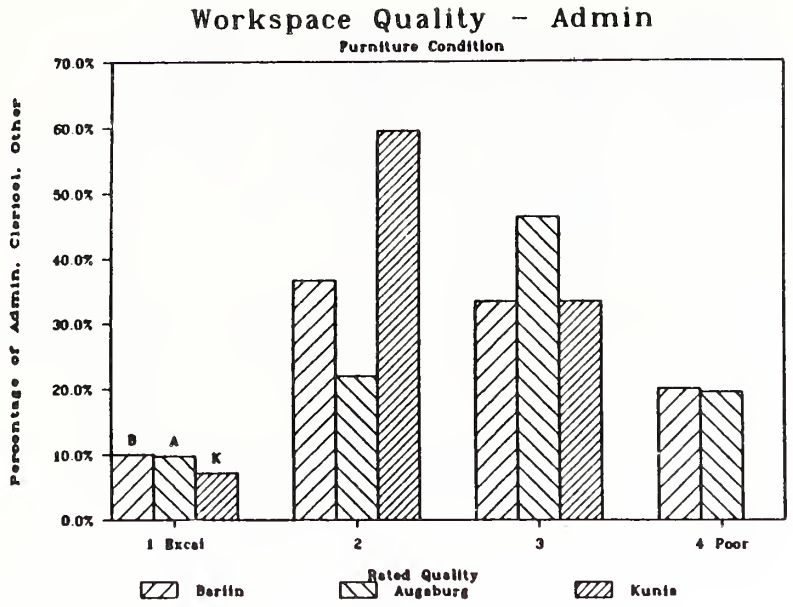
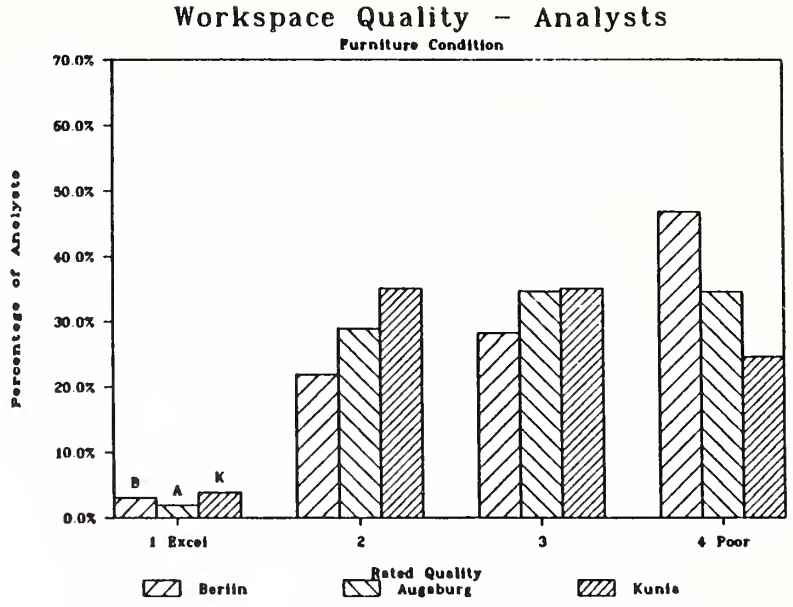


Figure 76. Percentage of People Rating the Quality of the Furniture in the Workspace





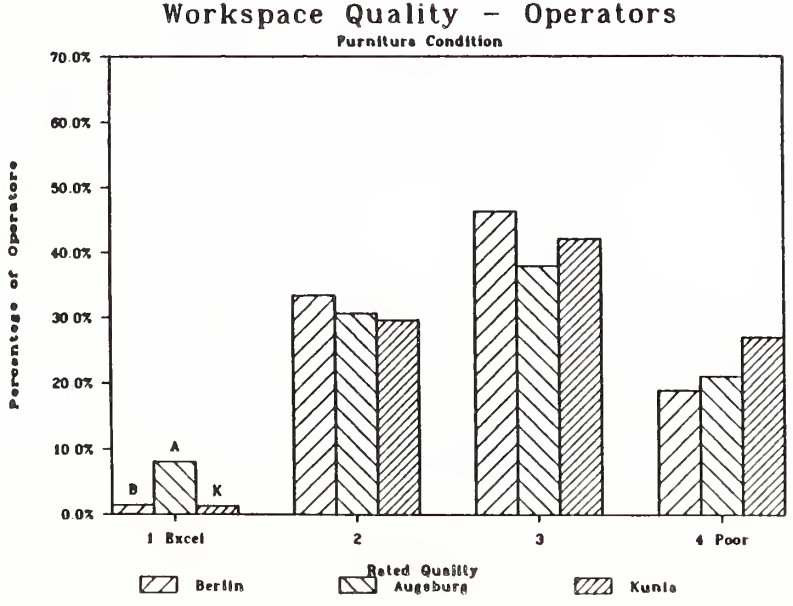
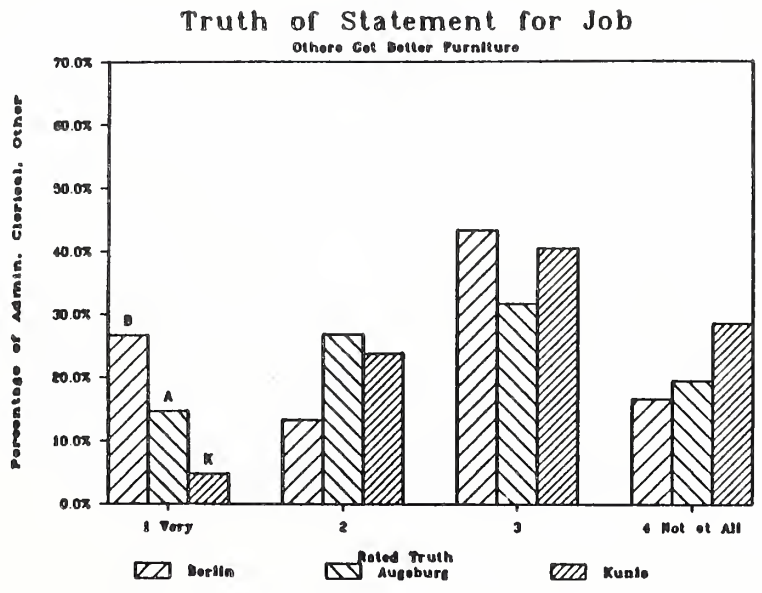
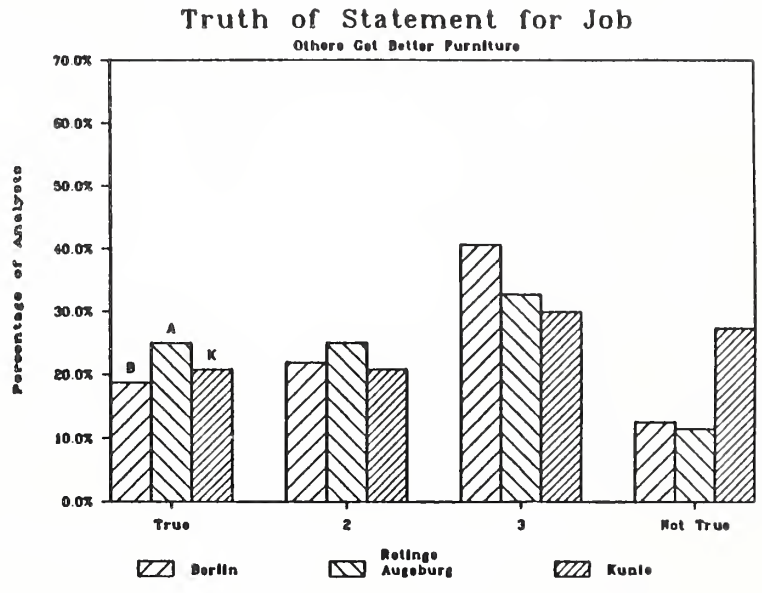


Figure 77. Percentage of People Rating the Overall Condition of Furniture in their Workspace





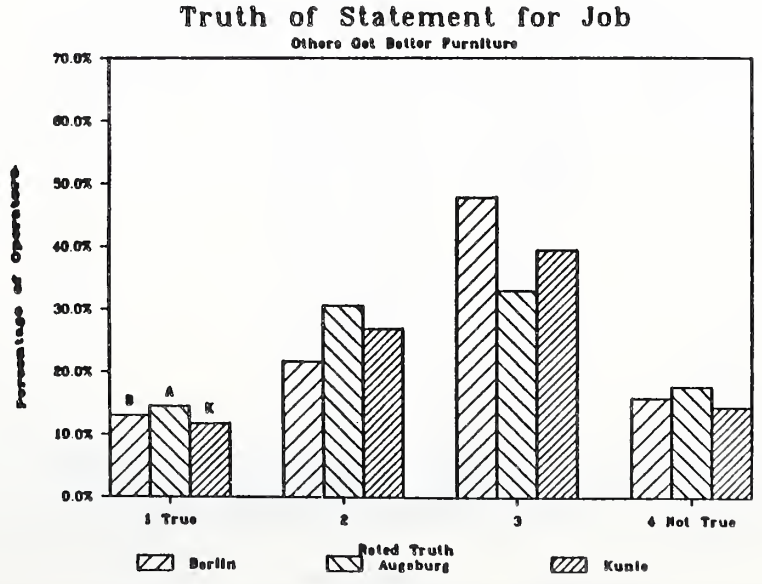


Figure 78. Percentage of People Indicating that Other People have Better Furniture than they have

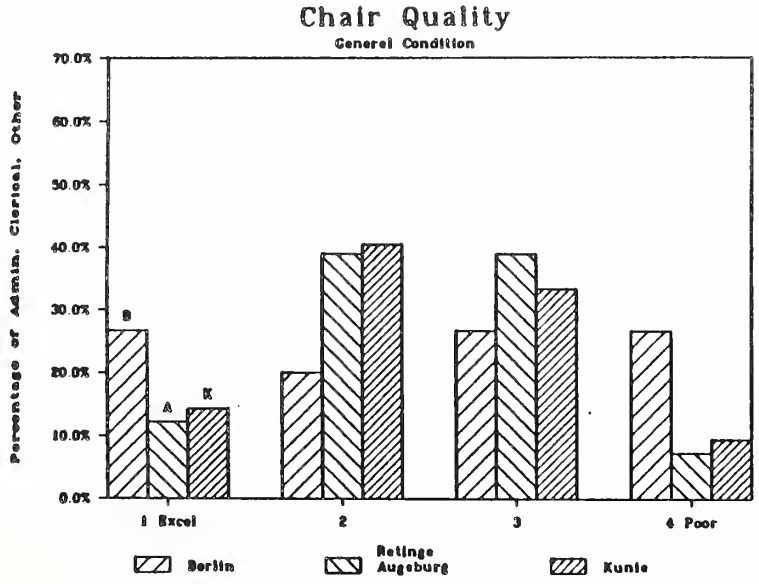
considered theirs "poor", and about 60 to 70% of all analysts considered their furniture "fair" or "poor". Operators tended to rate their furniture quality as "good" or "fair", although some 15 to 25% considered it "poor". Administrators at Kunia rated their furniture as "good" or "excellent", with none rating it "poor". Augsburg administrators were more negative, with about 60% rating their furniture as "fair" or "poor", while Berlin administrators rated theirs as "good" or "fair".

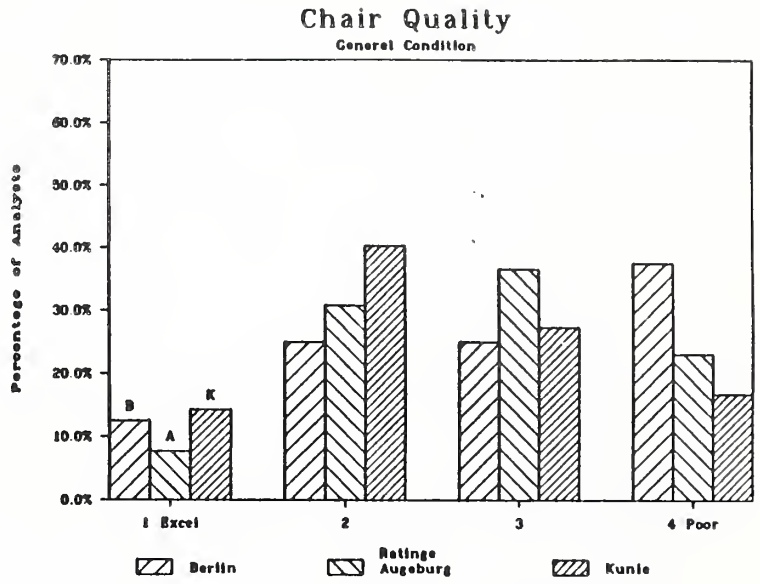
Figure 77 presents data on furniture condition. This figure suggests some striking differences among the groups in their perception of furniture condition. The administrators, in particular, were split; about 60% in Kunia considered their furniture condition to be "good", 45% in Augsburg considered theirs "fair", and 45% in Berlin "good" or "fair". Analysts judged their furniture condition as "good", "fair", or "poor", with about 45% in Berlin considering theirs "poor". Operators had similar opinions, regardless of site, about 40% regarding their furniture "fair", another 30% "good", and 20% "poor". Fewer than 10% of any group judged their furniture quality as "excellent". Figure 78 suggests that only 10 to 25% of all respondents believed the statement "others in the facility get better furniture" is "very true".

Figure 79 does not present any striking findings about overall perception of chair quality, although operators at Kunia and analysts in Berlin were more likely to rate their chair as "fair" or "poor". Figure 80 indicates, however, that the inability to adjust the back of the chair was seen as a problem by almost all respondents, with 40 to 55% rating this ability as "poor". The only exception was operators in Berlin who had recently received an equipment upgrade which included chairs. Figure 81 indicates that the chair was not "particularly bothersome" for VDT use, with fewer than 30% rating this as "somewhat" or "very bothersome". Similarly, chair comfort was typically rated as "good" or "fair" (figure 82). Operators in Kunia tended to rate it as "good", "fair", or "poor", while operators at the other two sites were much more positive, with 50% rating chair comfort as "good".

The subjective assessment performed during the physical measures by the experimenters indicated that as many as 80% of the chairs in operations at Kunia were not considered to be in "good" condition, whereas about 70% of the chairs in administrative and analytical areas could be considered to be in "good" condition.

Figure 83 suggests that desk height caused relatively few problems, with fewer than 15% of respondents rating it as "somewhat" or "very bothersome". Figure 84 indicates that most people, except Berlin administrators, believed they had enough equipment. Personal interviews with people, however, often indicated major problems with equipment functioning. Finally, figure 85 suggests that "needing more time on a terminal" is not viewed as a problem, although again, interview data suggested the need for better and more terminals. Interview data are presented in the Appendix to the report by Rubin and Collins (1988).





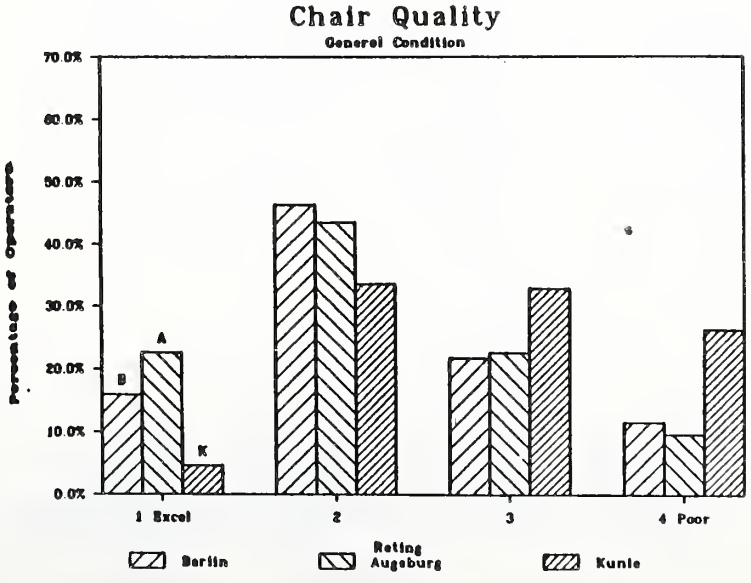
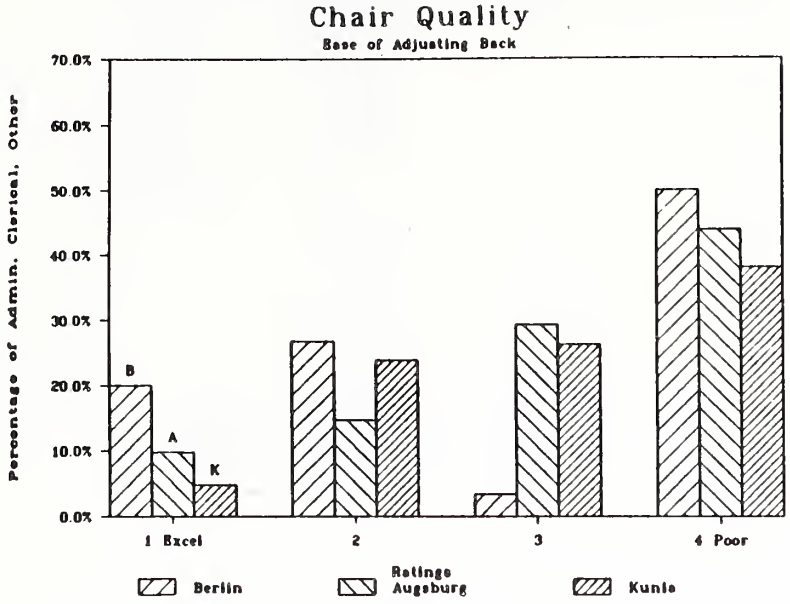
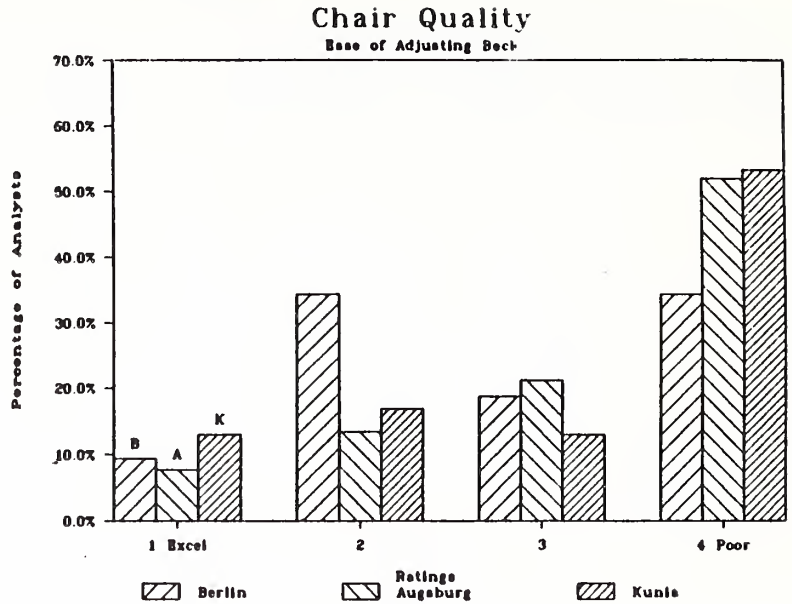


Figure 79. Percentage of People Rating the General Condition of their Chair





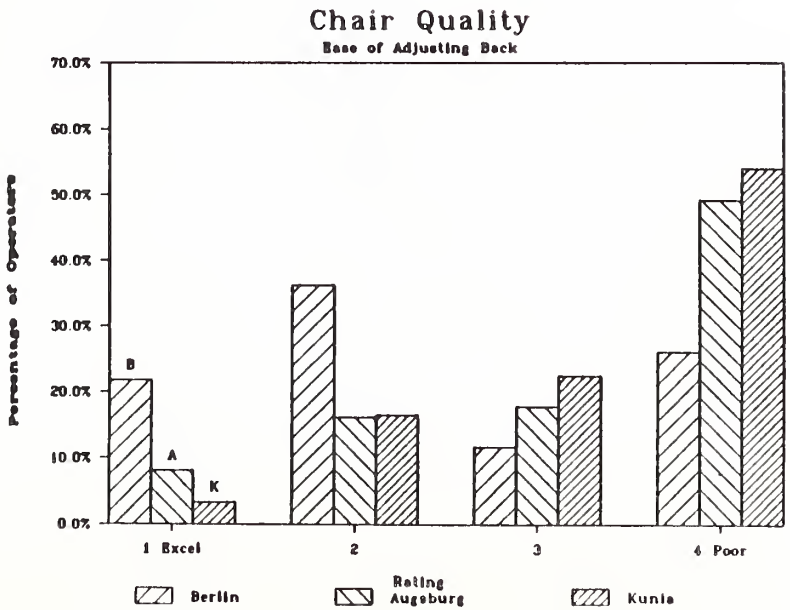
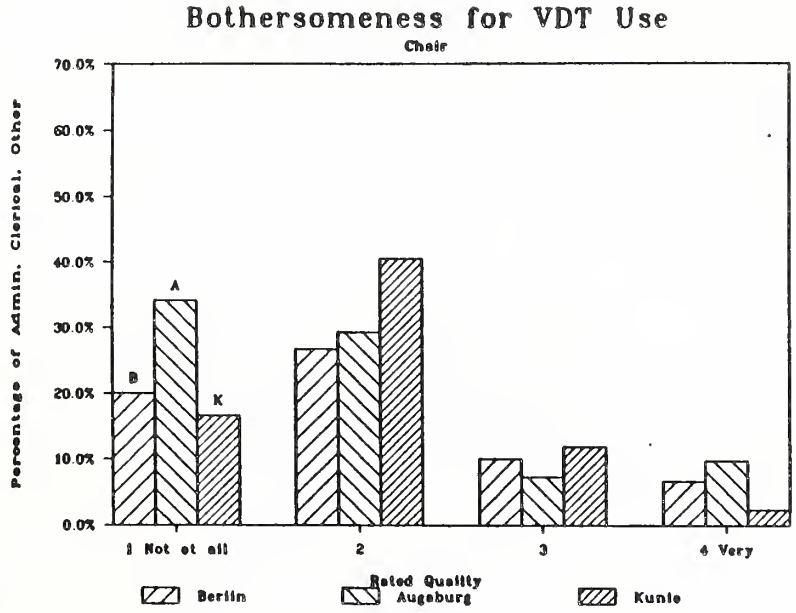
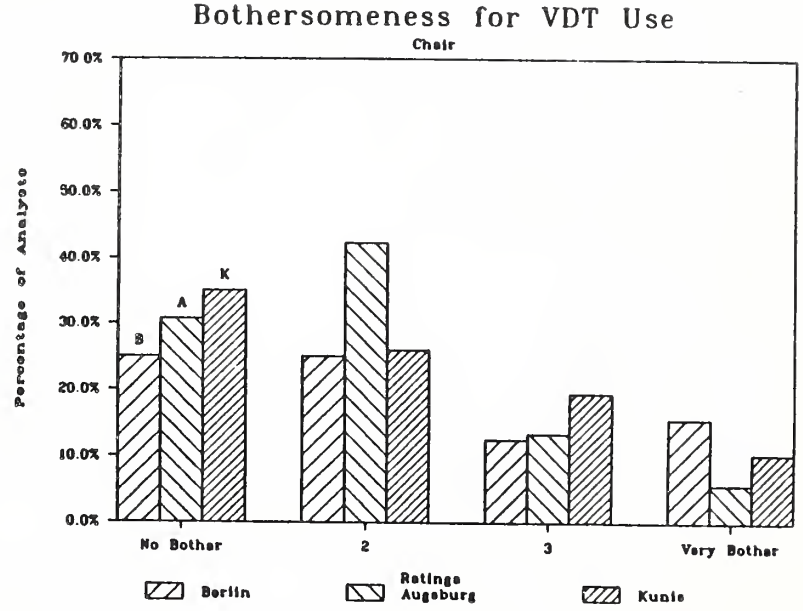


Figure 80. Percentage of People Rating the Ease of Adjusting the Back of their Chair





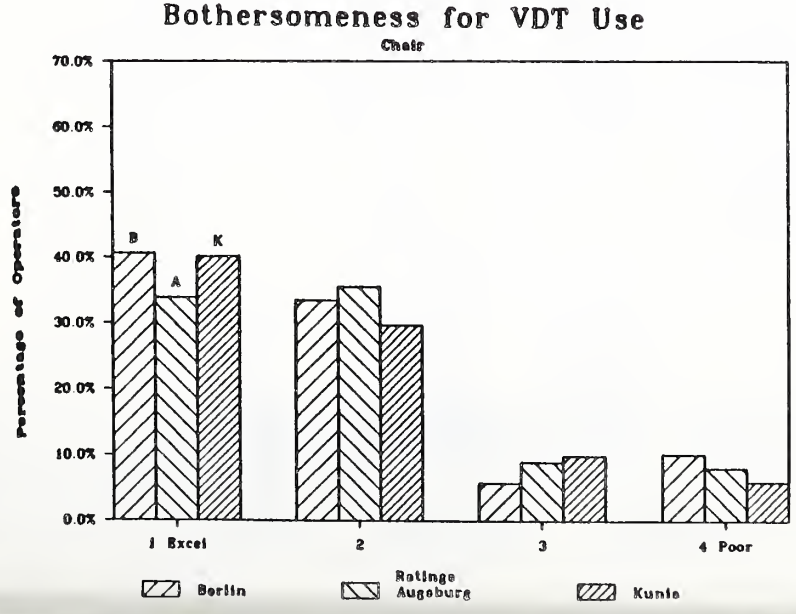
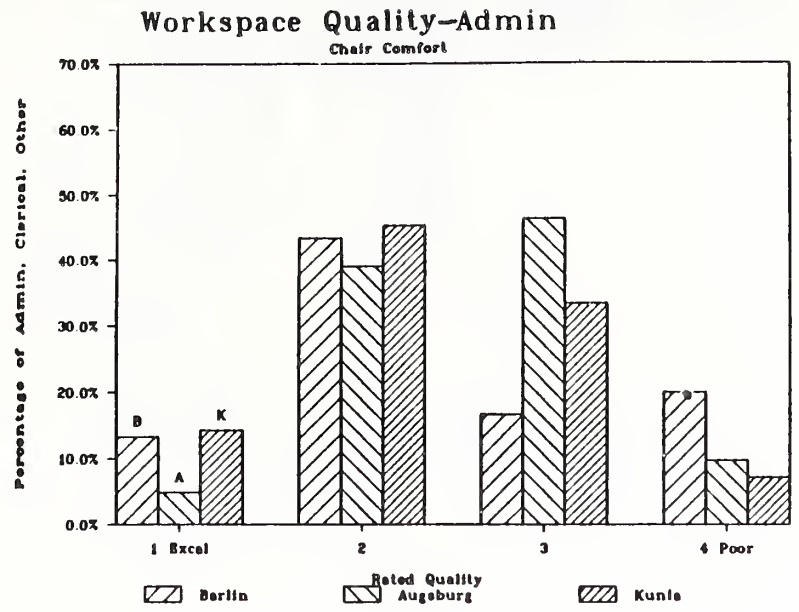
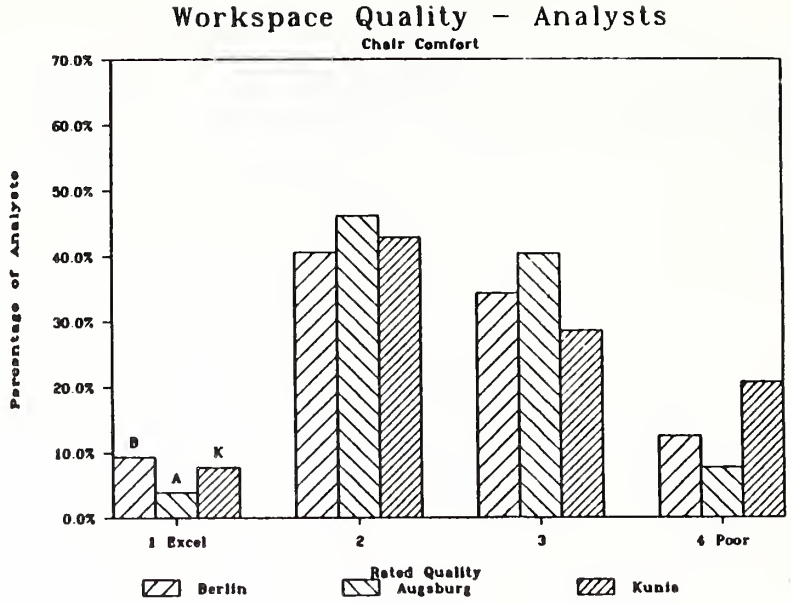


Figure 81. Percentage of People Indicating that their Chair is Bothersome for VDT use





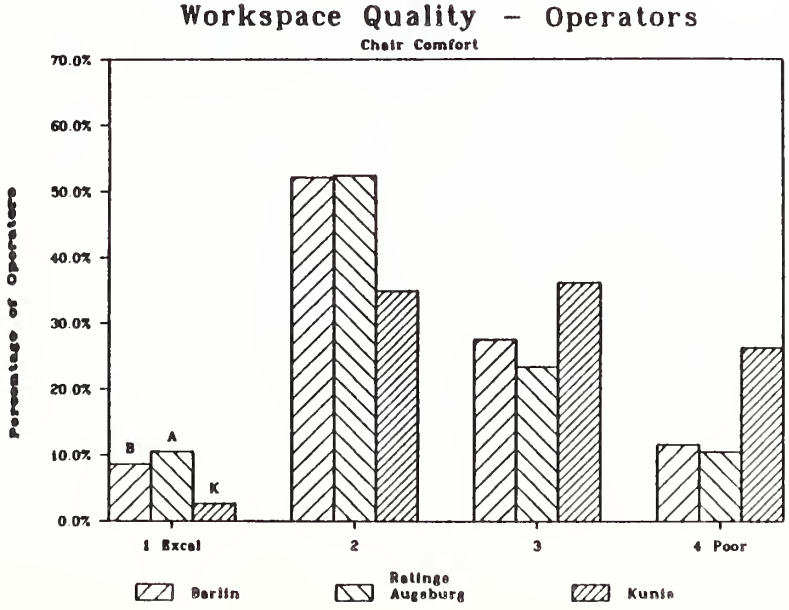
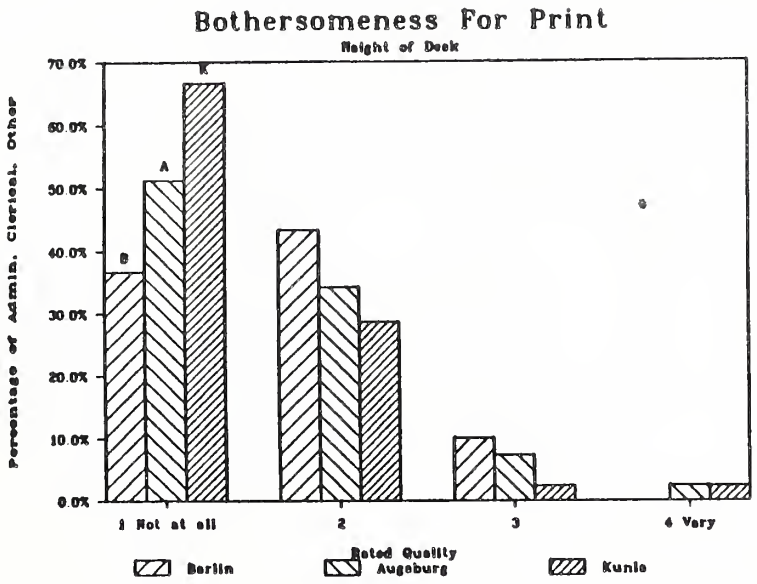
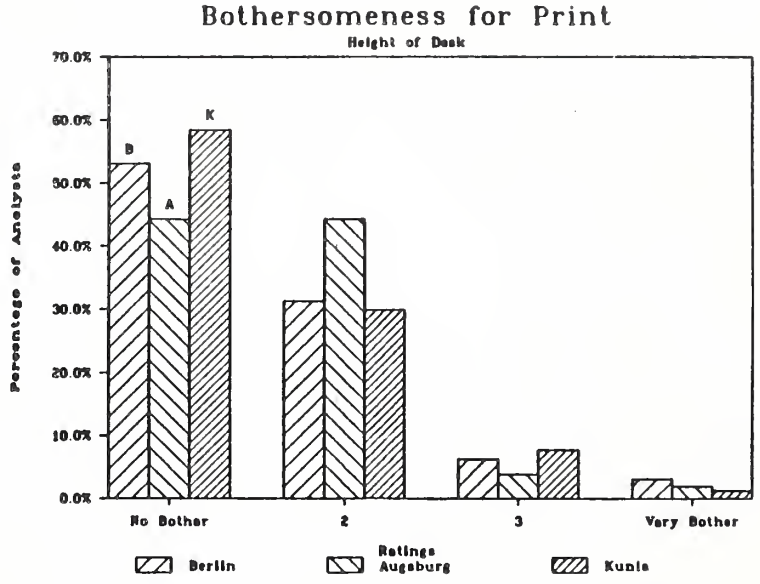


Figure 82. Percentage of People Rating the Overall Comfort of their Chair





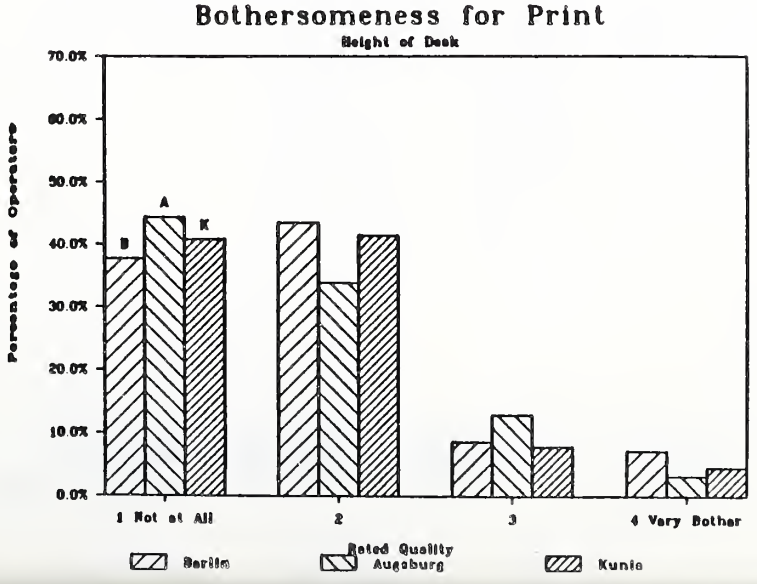
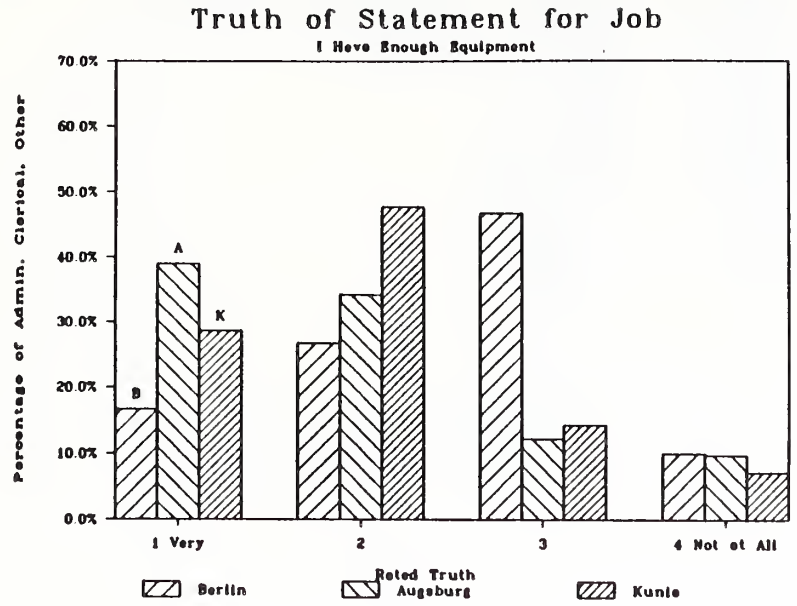
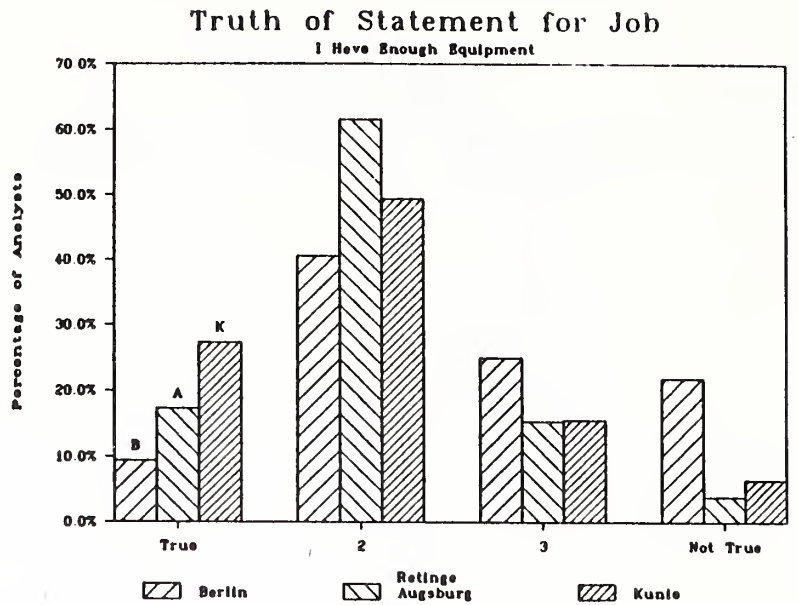


Figure 83. Percentage of People Indicating that the Height of the Desk is Bothersome for Print Tasks





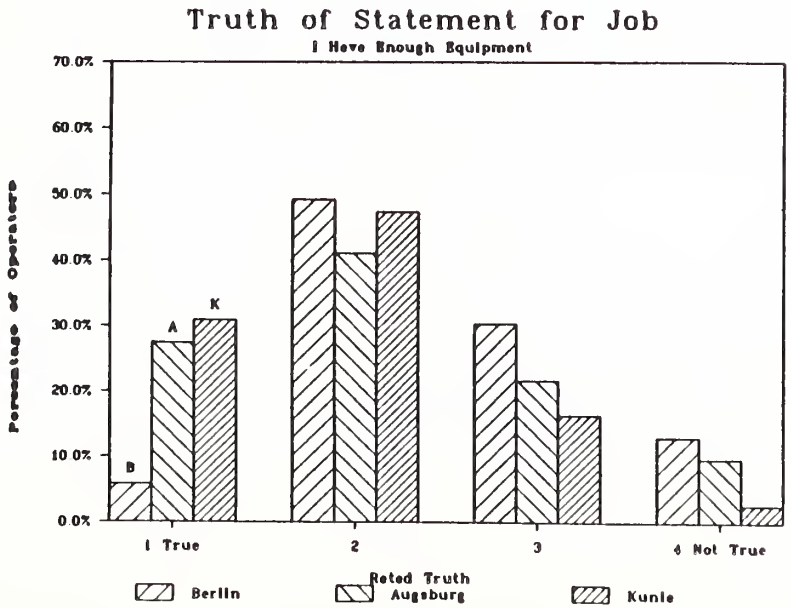
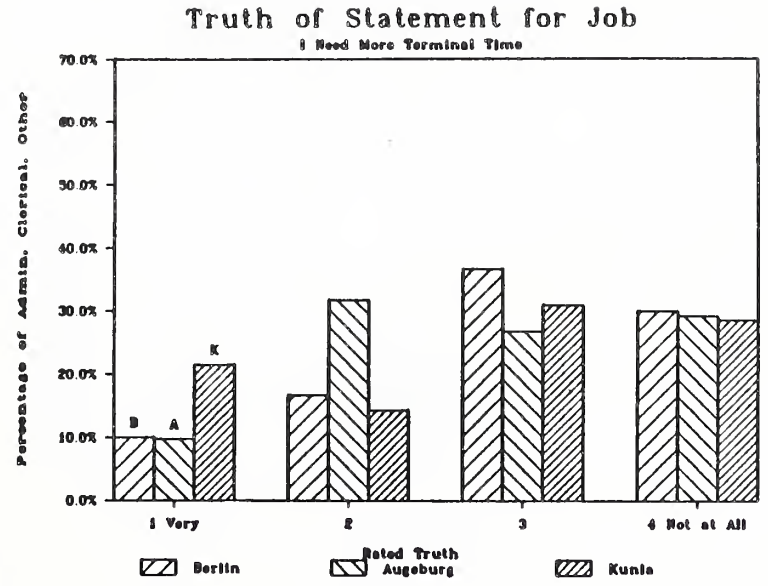
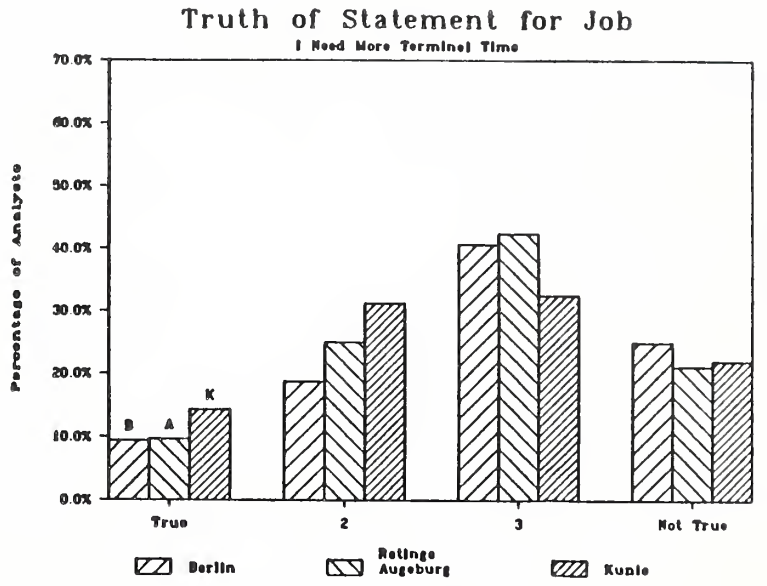


Figure 84. Percentage of People Indicating that they have enough Equipment to do their Job





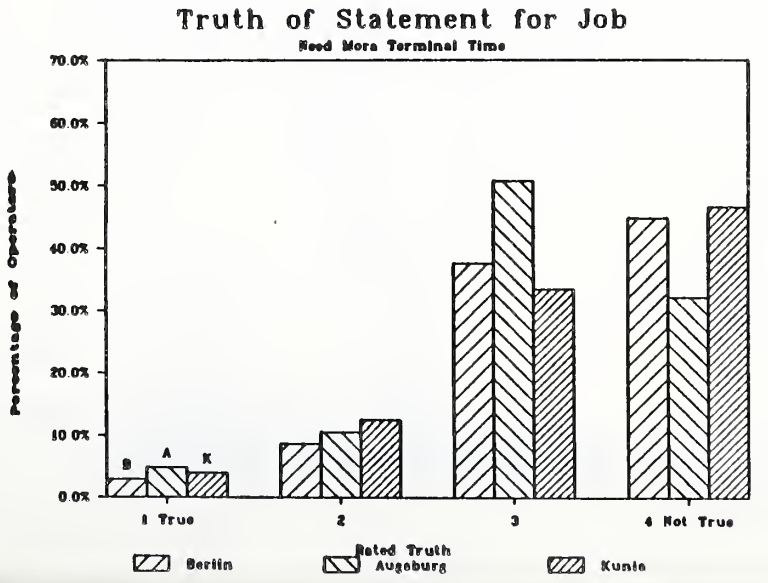
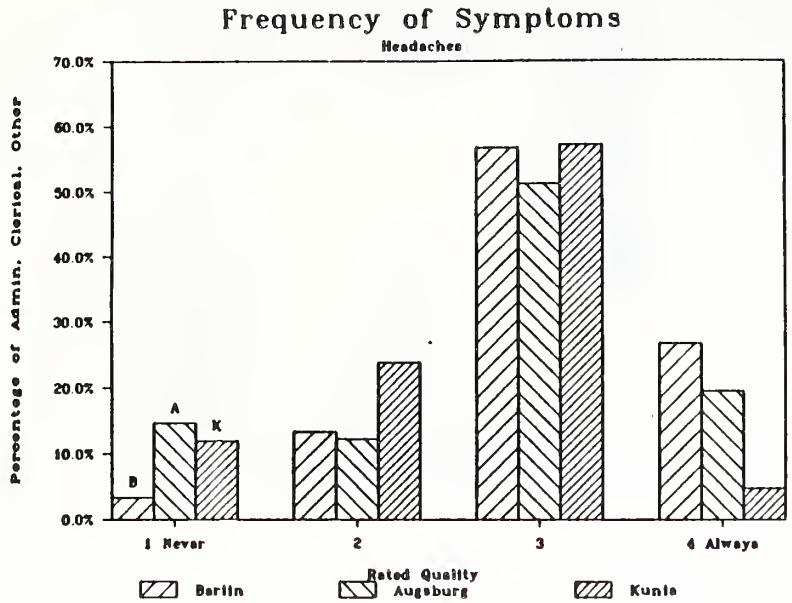
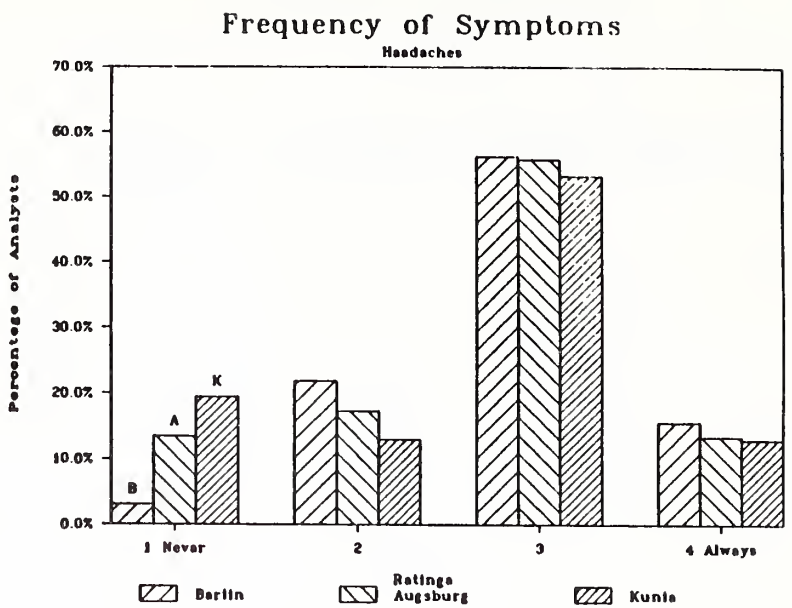


Figure 85. Percentage of People Indicating that they Need More Time on a VDT to do their Work Properly





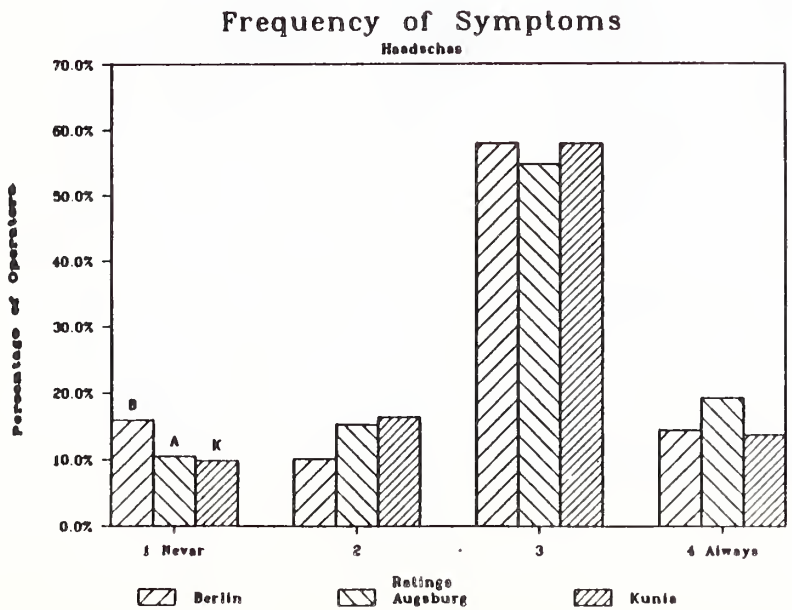
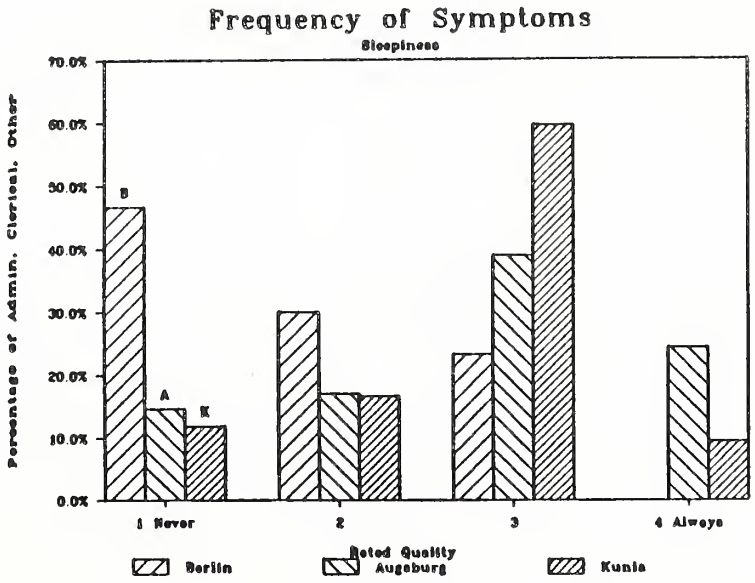
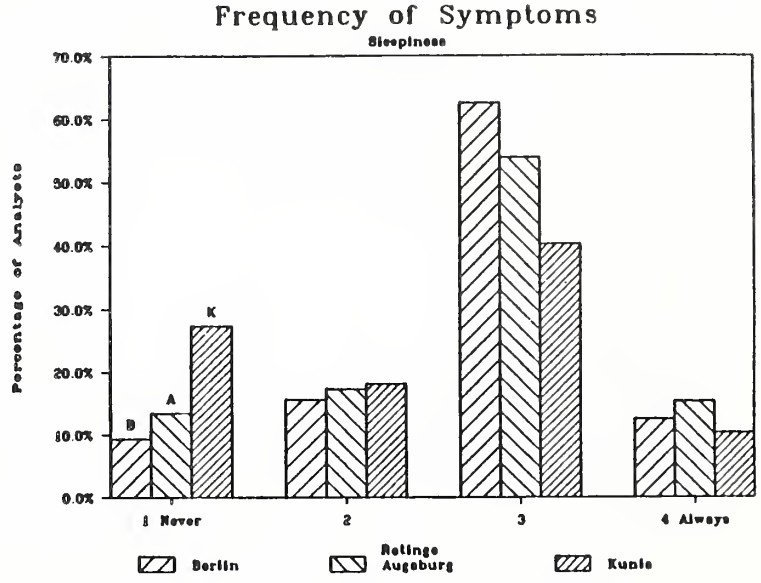


Figure 86. Percentage of People Indicating the Frequency with which they get Headaches





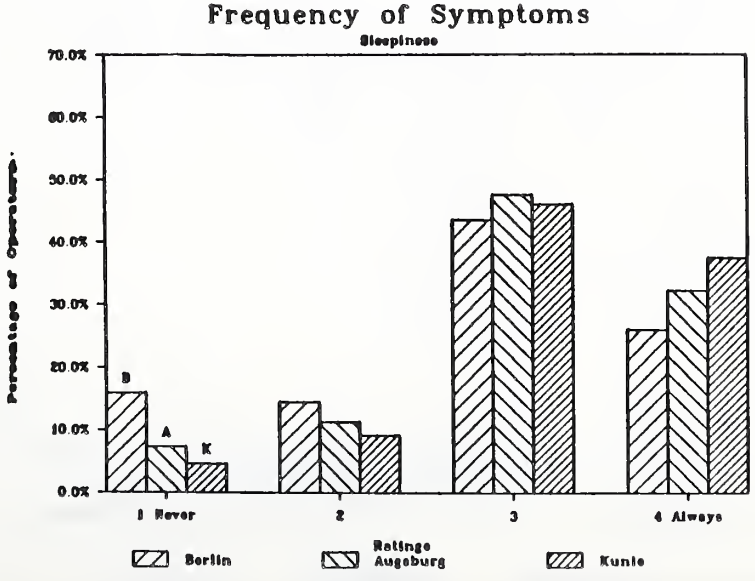
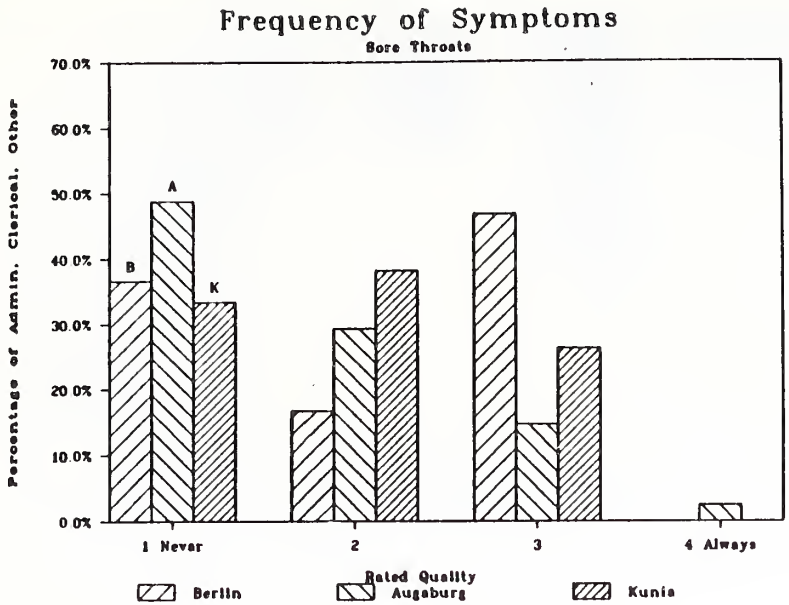
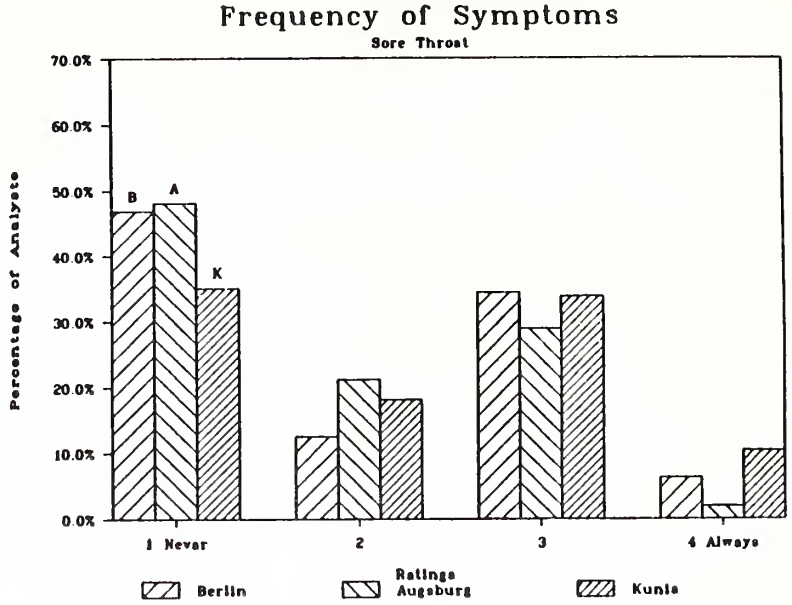


Figure 87. Percentage of People Indicating that they are Frequently Sleepy





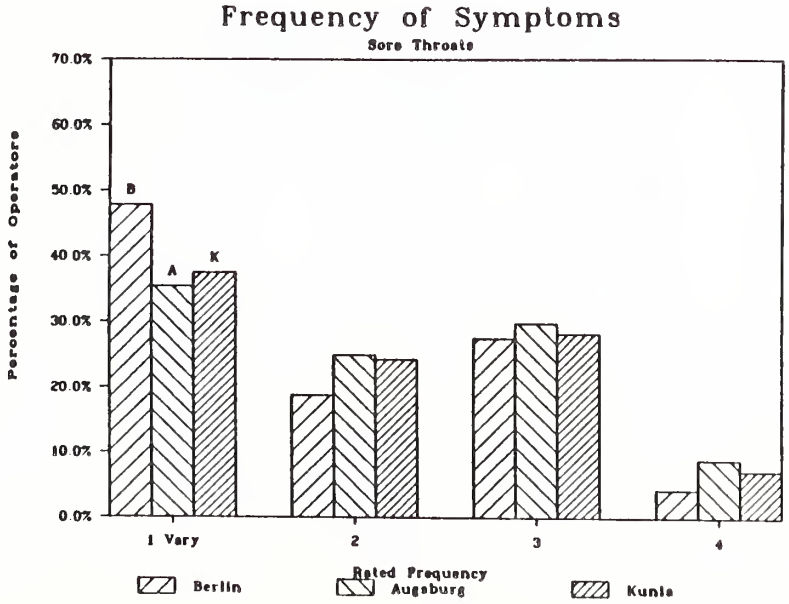
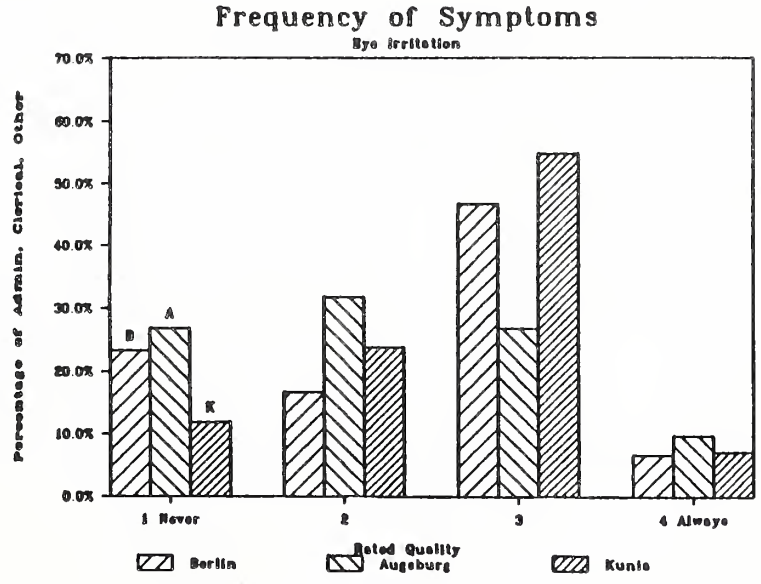
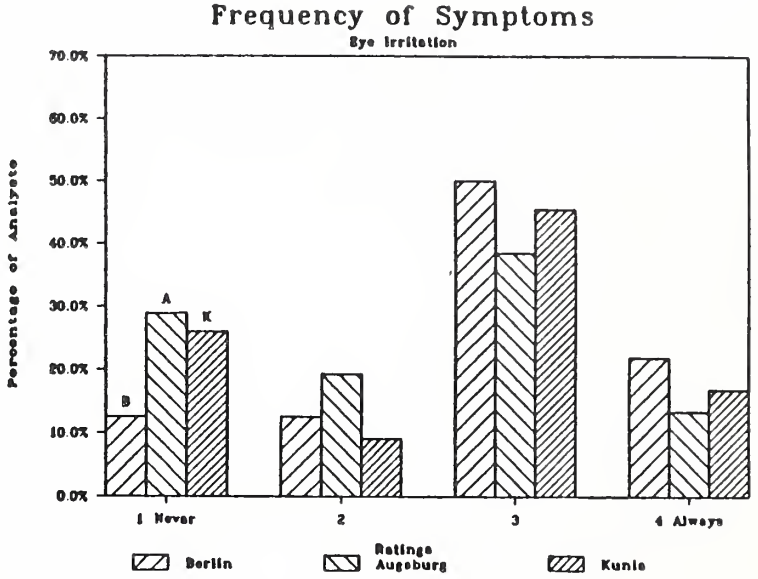


Figure 88. Percentage of People Indicating that they Frequently have Sore Throats





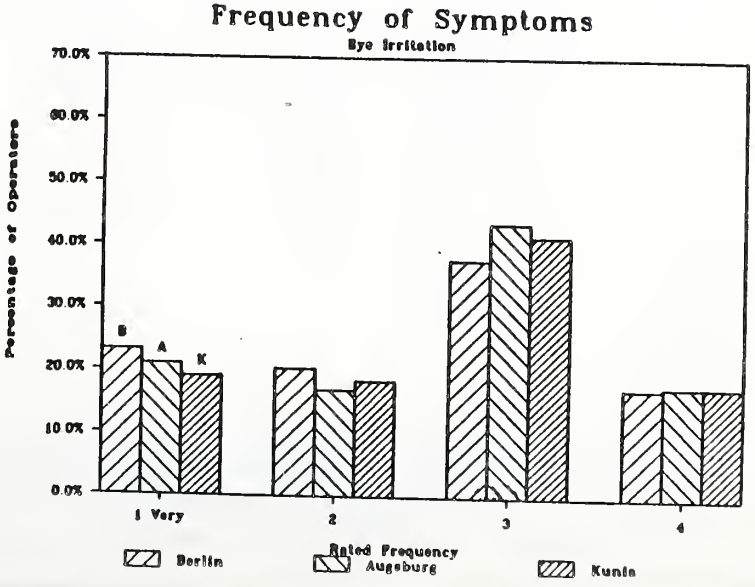
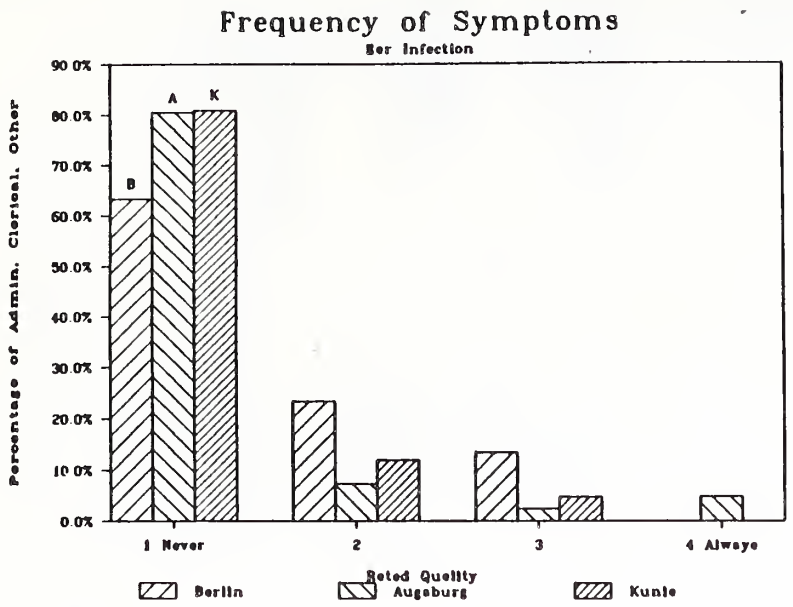
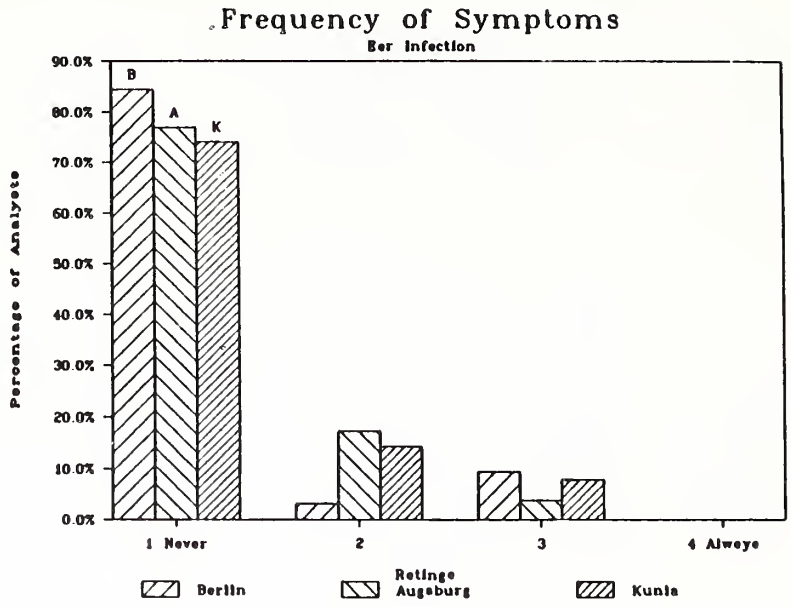


Figure 89. Percentage of People Indicating that their Eyes are Frequently Irritated





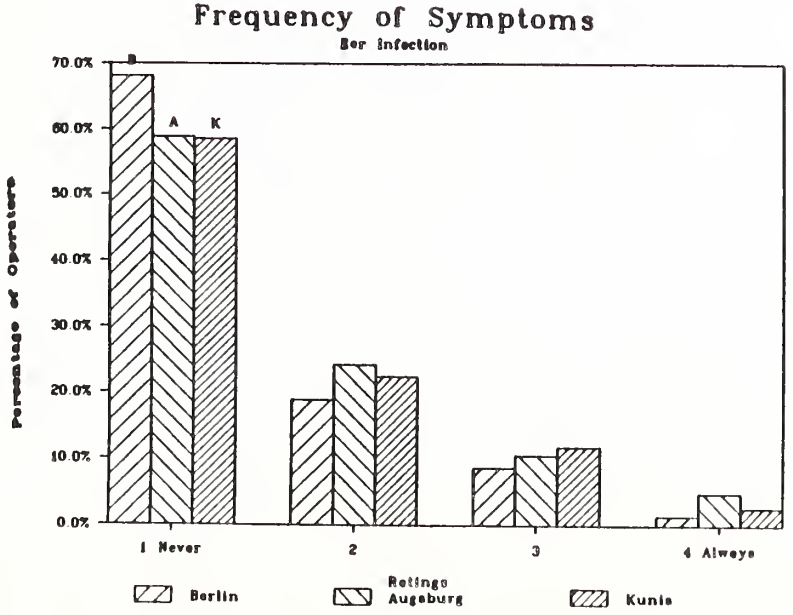
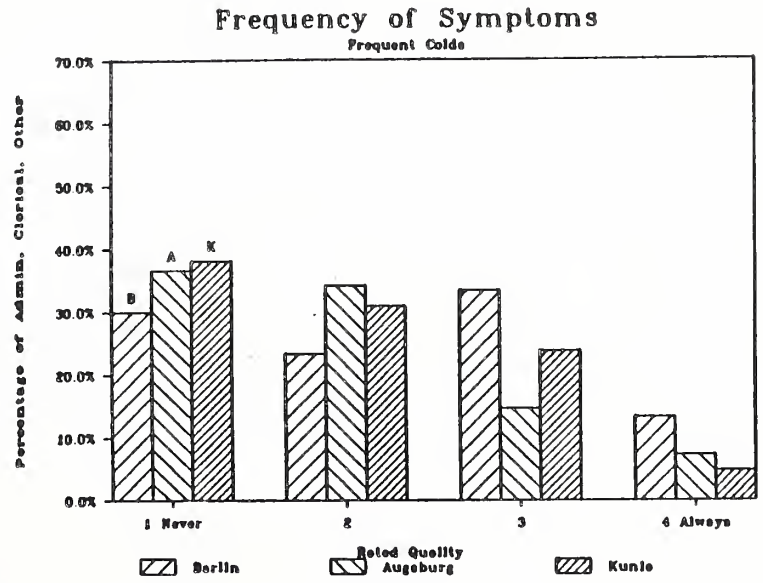
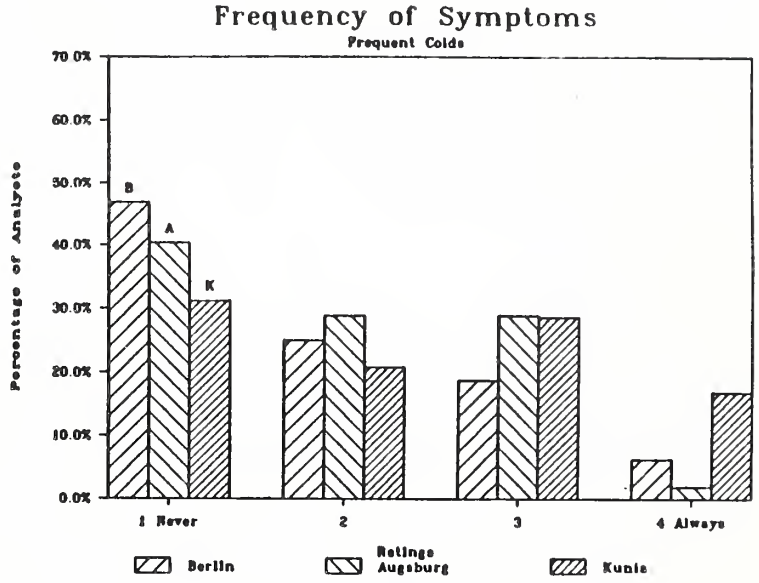


Figure 90. Percentage of People Indicating that their Ears are Frequently Infected





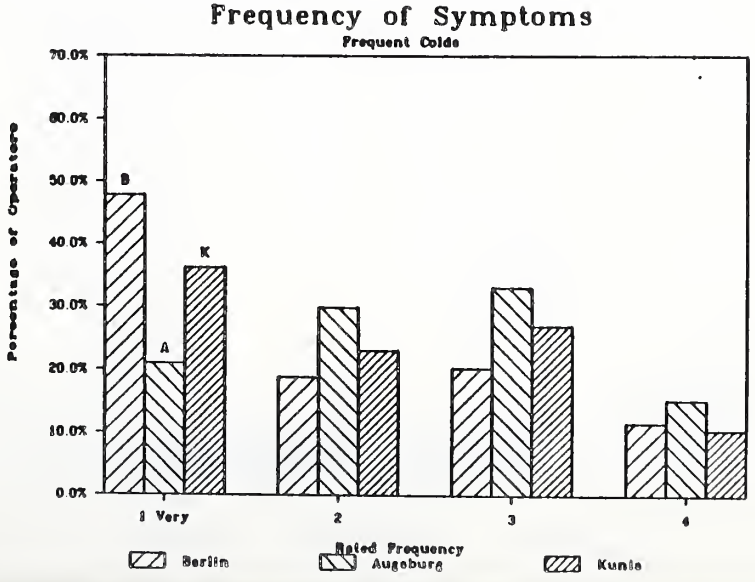
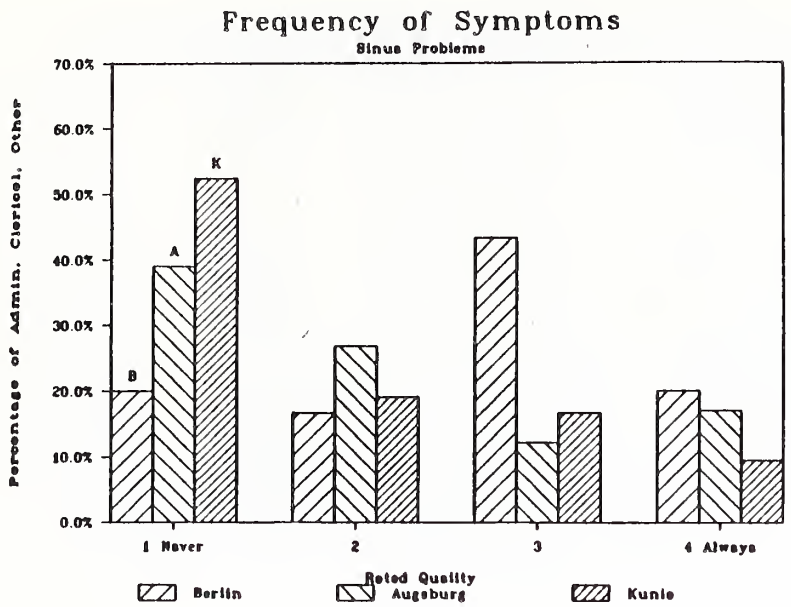
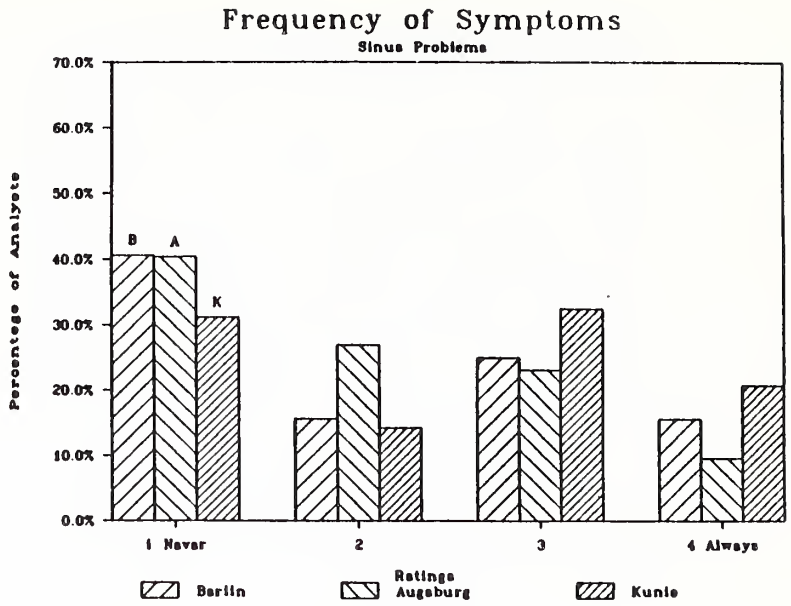


Figure 91. Percentage of People Indicating that they have Frequent Colds





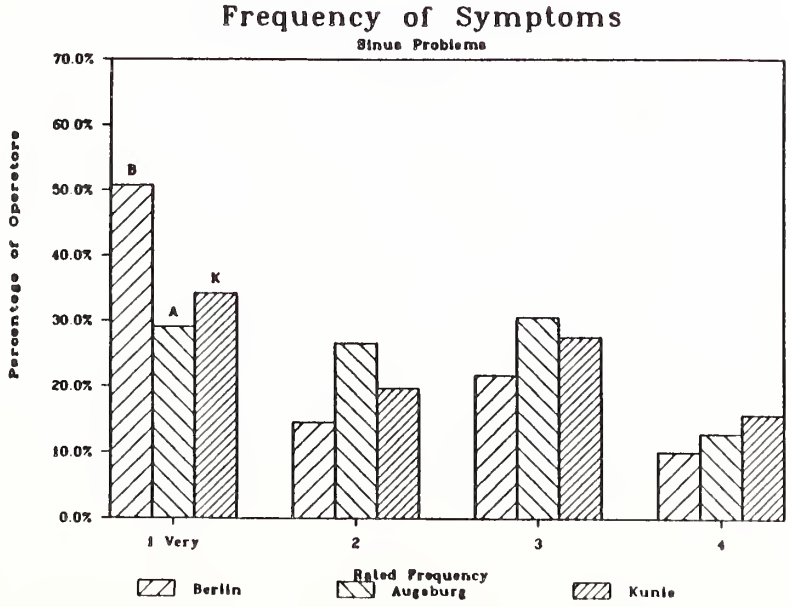


Figure 92. Percentage of People Indicating that they Frequently have Sinus Problem

3.7 Response to Physical Well-Being

Figures 86 to 92 deal with the physical well-being of the personnel. Figure 86 indicates that frequent headaches were common with 50 to 70% reporting headaches "sometimes" or "always". Sleepiness was also a problem, with 40 to 70% of the sample reporting being sleepy "sometimes" or "always" (Figure 87). In fact, 30 to 40% of the operators indicated they were "always" sleepy, while another 40% were "sometimes" sleepy. Of interest, 60% of the administrators in Kunia also reported being sleepy some of the time even though they all worked a day shift. The sleepiness may reflect an indoor air quality problem. Figure 88 suggests that sore throats were "never" a problem for 35% to 50% of the respondents. Yet about 45% of Berlin administrators reported sore throats "sometimes", as did about 25-30% of all analysts and operators. Figure 89 indicates that eye irritation was more of a problem than sore throats with 40 to 60% reporting it occurring either "sometimes" or "always". Ear infection never occurred for 60 to 85% of the respondents, according to figure 90. Figure 91 indicates that the frequency of colds appears to be fairly evenly divided among "never", "rarely", and "sometimes", with only 5 to 15% indicating that colds are "always" a problem. Figure 92 indicates that sinus problems were a problem for Berlin administrators and Kunia analysts. Nonetheless, only 10 to 20% of all respondents indicated they always have sinus problems.[2]

3.8 Desired Changes to the Facility

Some of the most interesting results are shown in Figures 93 to 95 which present data on the changes that people would like to make to their space. They were asked to list the 4 changes they would most prefer, and give reasons for their choices. Each figure presents data for each of the three groups at a site. The percentage of people in an individual group picking a given choice is shown on the ordinate; the choices are given on the abscissa. Data for the first, second, third and fourth choice are combined into a single bar, although the percentage of each choice is indicated by a different stripe code.

Examination of figure 93 for Berlin indicates that a better year round temperature was the most desired change. It was the most frequently occurring first choice, and was picked by 55 - 65% of each group as one of the four choices. For administrators, other choices selected by 30% or more respondents included less noise, better break area, adjustable task lighting, and improved air circulation. Analysts chose color of furnishings and walls, adjustable task lighting, and improved lighting.

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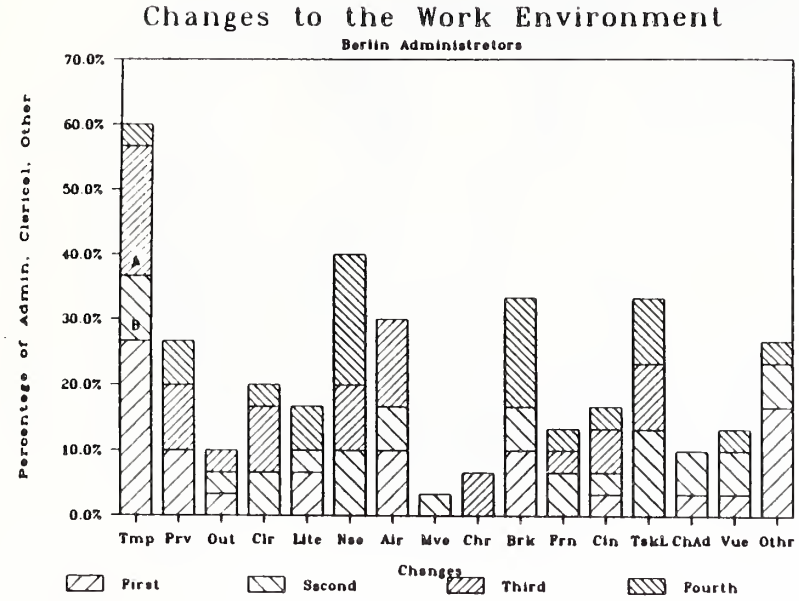
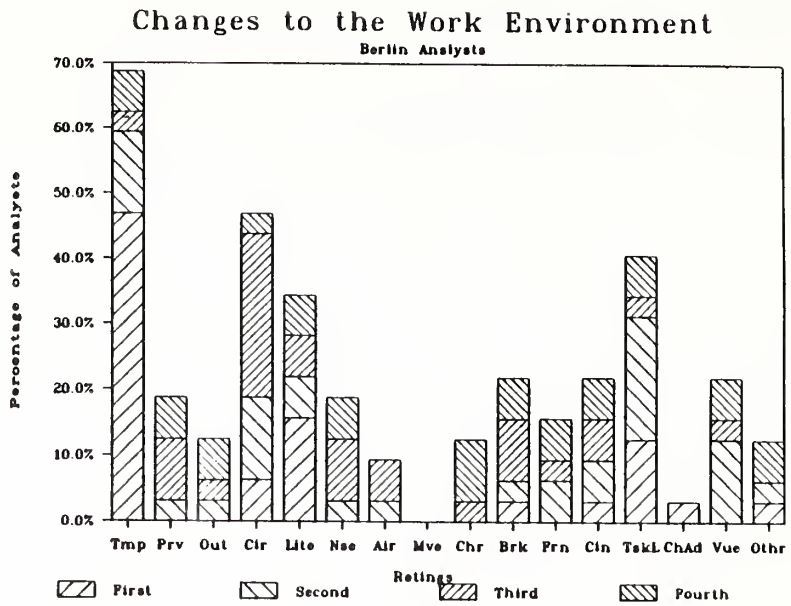
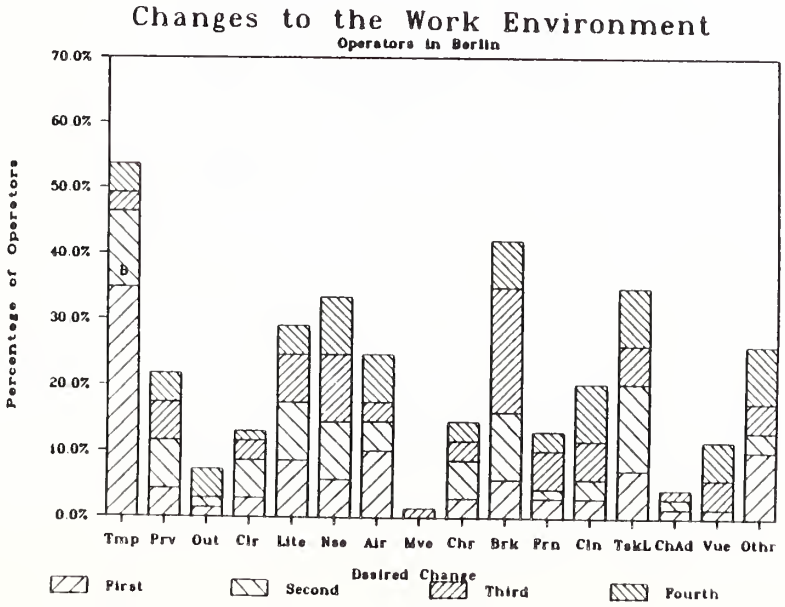
[2]One problem with the data on health issues may be the scale used to assess frequency of occurrence. Categories of "never", "rarely", "sometimes", and "always" were used. A five point scale inserting "frequently" between "sometimes" and "always" would probably have been a more sensitive indicator of people's health.

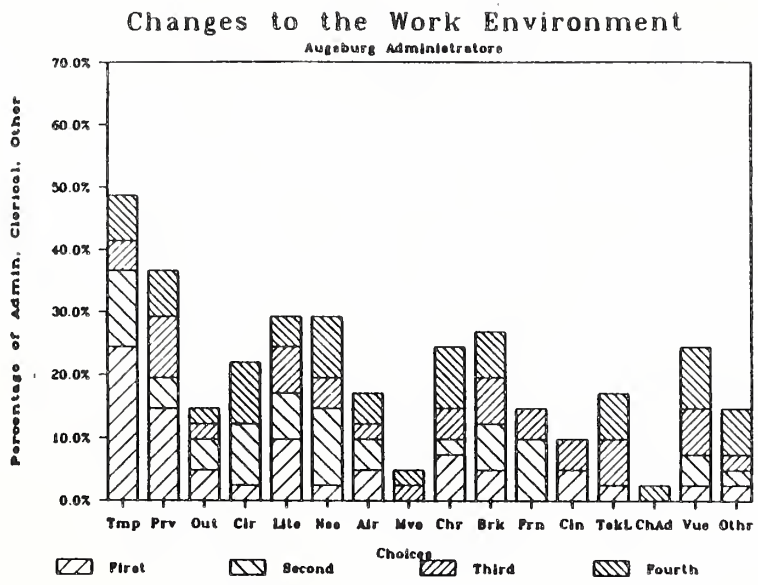


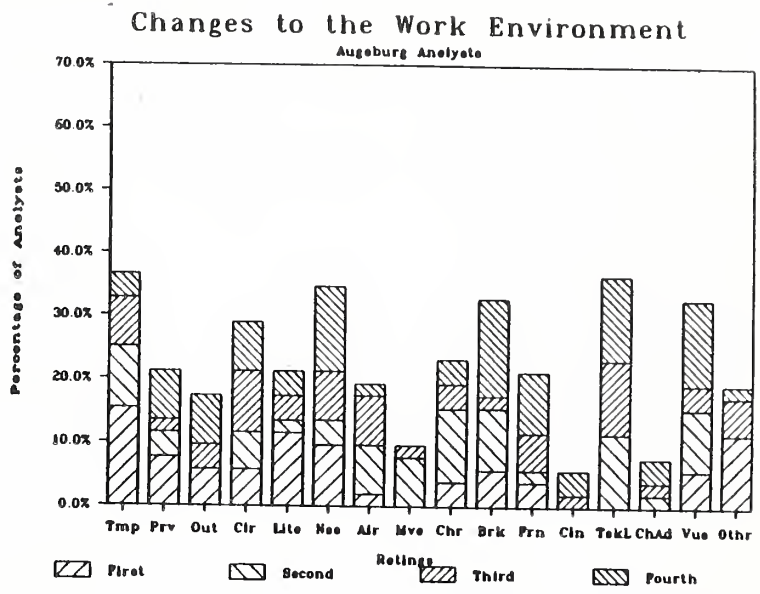




In fig. 93-96, the abbreviations refer to the choices on the questionnaire for question 24, shown on p156. Specifically, "Temp" refers to better temperatures, "Prv" to more privacy, "Out" to access to outside, "Clr" to color in the office, "Lite" to improved lighting, "Nse" to less noise, "Air" to improved air circulation, "Mve" to move further, "Chr" to more comfortable chair, "Brk" to break areas, "Frn" to furnishings, "Cln" to cleaning, "Tskl" to task lighting, "Ch Ad" to adjustable chair, "Vue" to simulated view out, and "Othr" to other.

Figure 93. Choices for Desired changes to the Facility in Berlin





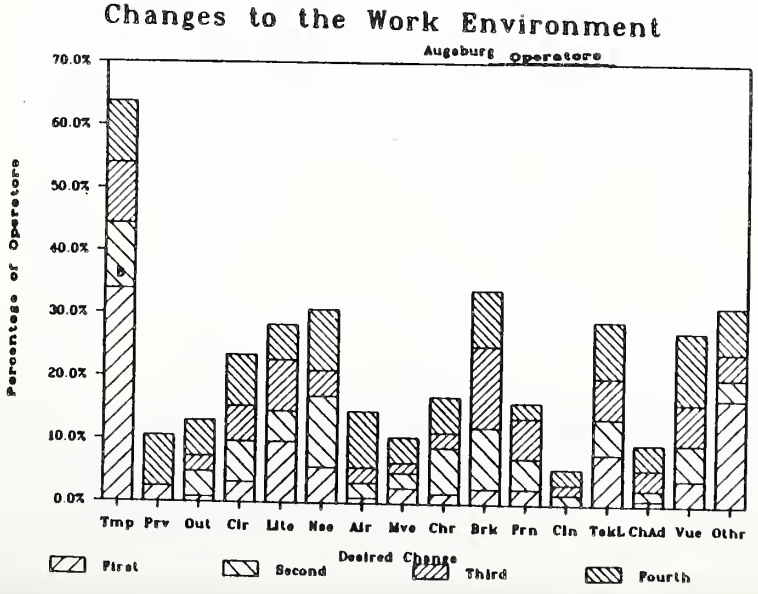
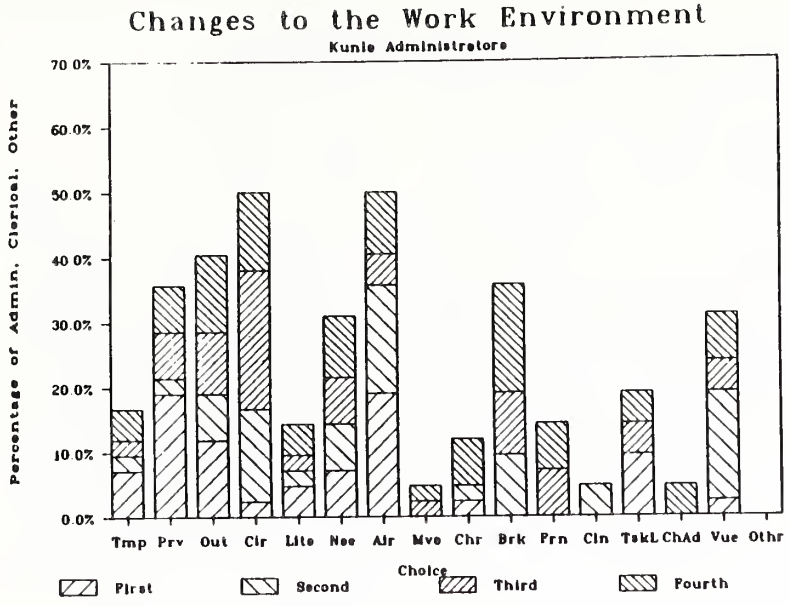
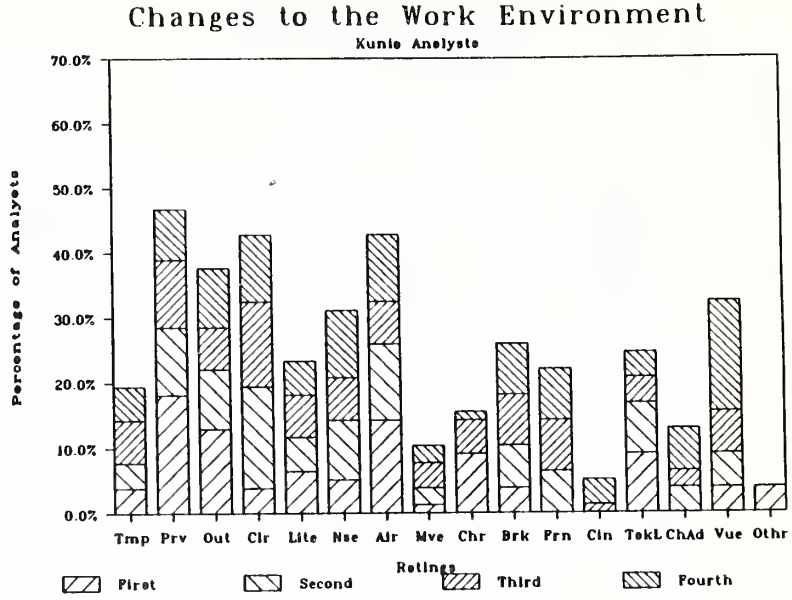


Figure 94. Choices Selected as Desired Change to the Facility in Augsberg





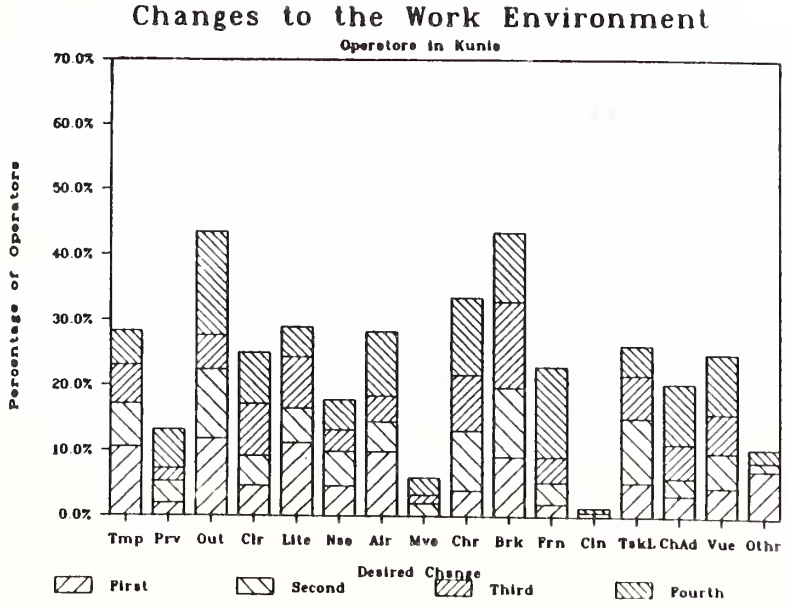


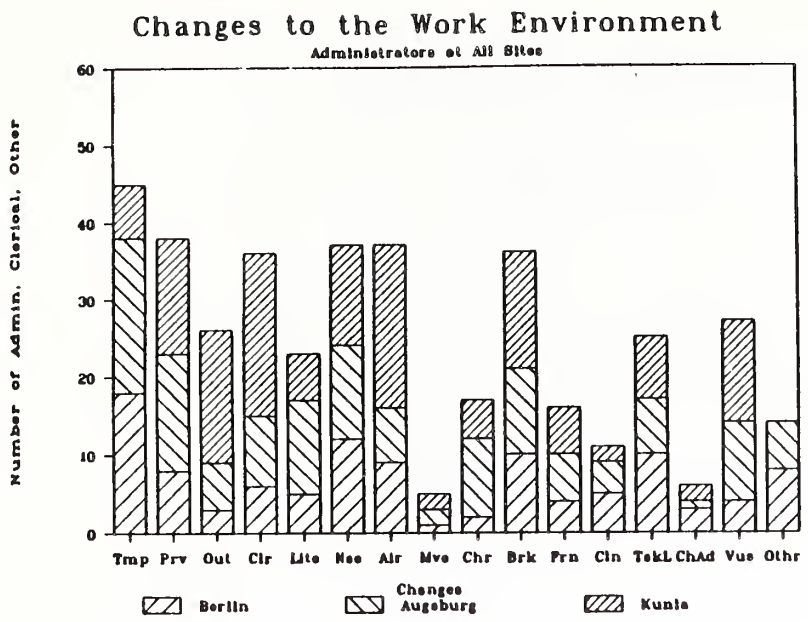
Figure 95. Choices Selected as Desired Change to the Facility in Kunia

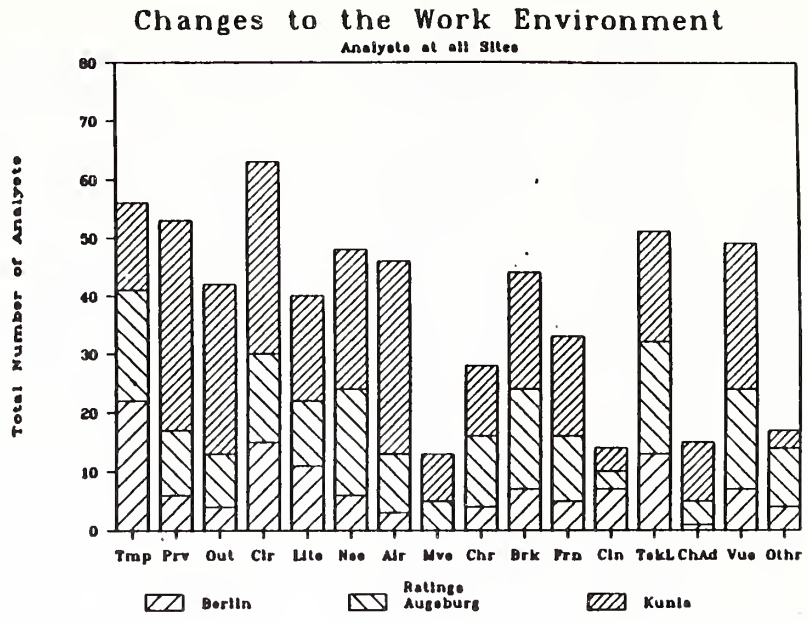
Finally, operators wanted a better break area, improved task lighting, less noise, and improved lighting. Administrators and operators also selected "other" with many comments related to improving equipment.

Figure 94 presents the choice data for Augsburg. At this field station, temperature was also the first choice for each group, but a greater percentage of administrators (almost 50%) and operators (almost 65%) picked this as one of the four, perhaps as a result of the generally colder temperatures. Only 35% of the analysts included this as their first choice. Administrators in Augsburg also wanted more privacy, improved lighting, less noise, and better break area, although about 25% also opted for view out and a more comfortable chair. The analysts' choices were less clear cut, with 30 to 35% expressing a desire for better temperatures, task lighting, less noise, better break areas, view out, and improved colors. Operators in Augsburg clearly felt most strongly about improving room temperature, followed by break area, other, noise, task lighting, general lighting, and view out. Again, most of the "other" comments related to improving equipment performance.

Finally, data given in figure 95 for Kunia indicated that temperature was not the most frequent first choice. Administrators picked improved air circulation, operators wanted access to the outside, and analysts selected privacy as their first choices. Administrators at Kunia also picked color, access to the outside, privacy, better break area, and view out as desired changes. Analysts named improved air circulation, color, access to the outside view out, and less noise as their choices. Finally, operators picked better break area, chair comfort, and lighting as their most desired choices. Operators also expressed a desire for improved temperatures, better air circulation, task lighting and view out. It is interesting to note that access to the outside and view out emerged as frequent choices at Kunia (40%) but were rarely selected at the other sites. Kunia is the only truly windowless site; the cafeteria and main break areas at Berlin and Augsburg have windows. At Kunia, however, it is a 10-minute walk through the tunnel to the outside. Private conversations suggested that the desire for a view out and access to outside was quite strong at Kunia. Where schedules permitted, people made arrangements to run or jog over lunch and simply lengthened their work day. This option, however, was not available to operators, who often ate meals on position; and who were restricted by their shift schedules.

Figure 96 presents another way of looking at the choice data. Here, the choices of each type of group are combined for all sites. The number of administrators, analysts, or operators for all sites is given on the ordinate; choice was again given on the abscissa. This figure suggests that temperature is the first choice for administrators and operators while color is the first for analysts. Administrators at all sites also picked privacy, color, noise, air circulation and break area, while analysts selected temperature, privacy, task light, view out, noise, and air circulation. Finally, operators cited break area, task lighting and general lighting as their choices for improving their workspace.





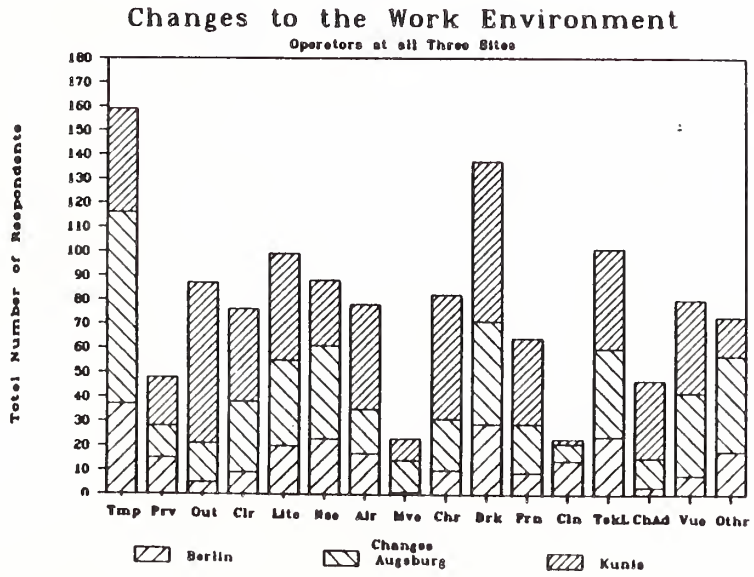


Figure 96. Choices Selected as Desired Changes by Different Job Categories for all Sites

4. Suggestions for Improvements to the Facilities and Equipment

4.1 Suggestions for Lighting

Each person was given a chance to list changes that they would make to improve the lighting, the workspace, and the equipment. Unlike the question about desired changes, these three questions were open-ended, allowing people to express themselves freely. Their responses are categorized and summarized in tables 1-3.

Table 1 presents a summary of the suggested changes to lighting. Comments for administrative personnel are presented first, followed by those for operators and for analysts. Data for Berlin, Augsburg and Kunia are presented for each type of personnel. The number of personnel commenting on a given change varies, because not all respondents answered all of the open-ended questions.

Table 1 indicates that for administrative personnel, issues related to control of lighting such as adjustable lighting, task lighting, and amount of light, were the most frequently mentioned changes at Berlin and Kunia. At Augsburg, however, maintenance issues (including flicker) were listed by 43% of those responding. For operators, control over lighting was important at all three sites, with people mentioning the need for better placement of lights and control of glare as needed changes in addition to changes in task lighting, adjustable lighting and light levels. People also mentioned light color and expressed a desire for more incandescent lamps and fewer fluorescent lamps. At Augsburg, 45% mentioned the need for better maintenance and less flicker. Comments by the analysts at all sites stressed the need for control over lighting through the use of task lights and adjustable lighting. Analysts at Augsburg did not raise the issue of better maintenance.

4.2 Suggestions for Equipment Changes

Table 2 presents data on suggested changes to equipment at the three field stations. Comments by administrative personnel related to the need to modernize and maintain equipment, improve lighting, chairs and furniture, and obtain new word processors and computers. Operators at Berlin stressed the need to increase reliability of equipment, modernize and maintain equipment, including printers and computers, speed up systems, organize systems ergonomically, and inventory and maintain a stock of spare parts. In addition to these issues, operators in Augsburg raised issues related to copy machines, placement of the computer, storage space, and test equipment. For operators in Kunia, the major issue was that of modernizing equipment, including keyboards, VDT's, printers, and software. The need for improvements in space, chairs, noise, as well as the use of ergonomic considerations in designing equipment were also listed. Finally, 59% of the analysts in Berlin stressed the need to modernize equipment, with other issues related to speed and reliability of equipment. In Augsburg the major equipment

Table 1. Summary Comments About Improvements to Lighting
Question 14

Administrative, Clerical, Other Responses

Berlin COMMENT	Percent	Augsburg COMMENT	Percent	Kunia COMMENT	Percent
light, adj	37.5%	light, maintain	16.7%	light, less	28.6%
light, task	31.3%	light, adj	13.3%	light, more	21.4%
light, glare	12.5%	light, more	13.3%	light, task	14.3%
light, more	6.3%	light, less	10.0%	light, placemen	7.1%
light, rem fluor	6.3%	light, rem fluo	10.0%	light, bench	7.1%
light, less	6.3%	light, flicker	6.7%	light, adj	7.1%
		light, vary	6.7%	light, diffuser	7.1%
		light, color	3.3%	light, maintain	7.1%
		light, hum	3.3%		
		light, bench	3.3%		
		light	3.3%		
		light, uniform	3.3%		
		light, placemen	3.3%		
		light, VDT inte	3.3%		
Total Admin	100.0%		100.0%		100.0%

Operator Berlin Comment	%	Operator Augsburg Comment		Operator Kunia Comment	%
light, adj	23.1%	light, less	19.2%	light, less	29.3%
light, task	13.5%	light, task	19.2%	light, task	22.0%
light, less	11.5%	light, more	19.2%	light, more	17.1%
light, soft	9.6%	light, adj	11.5%	light, adj	9.8%
light, placement	9.6%	light, flicker	7.7%	light, glare	9.8%
light, glare	7.7%	light, maintain	5.1%	light, elim flu	4.9%
light, color	5.8%	light, glare	5.1%	light, cover	2.4%
light, incan	3.8%	light, rem fluo	3.8%	see sun	2.4%
light, maintain	3.8%	light, placemen	2.6%	light, diffuser	2.4%
light, uniform	1.9%	light, incandes	2.6%		
light, daylight	1.9%	light, daylight	1.3%		
light	1.9%	light, indirect	1.3%		
light, rem fluor	1.9%	see sun	1.3%		
light, snack bar	1.9%				
light, rack	1.9%				
Totals	100.0%		100.0%		100.0%

Analyst		Analyst		Analyst	
Berlin		Augsburg		Kunia	
Comment		Comment		Comment	
light, task	33.3%	light, task	33.3%	light, task	32.5%
light, glare	22.2%	light, less	22.2%	light, adj	22.5%
light, color	11.1%	light	11.1%	light, less	17.5%
light, placement	11.1%	light, adj	11.1%	light, more	10.0%
light	5.6%	light, glare	11.1%	light, overhead	5.0%
light, soft	5.6%	light, indirect	11.1%	light, glare	5.0%
light, indirect	5.6%			light, soft whi	2.5%
light, rem fluor	5.6%			skylight	2.5%
light, incan					2.5%
	100.0%		100.0%		100.0%

Table 2. Desired Changes to Equipment Question 22

Administrative, Clerical, Other

Berlin		Augsburg		Kunia	
Comment	%	Comment	%	Comment	%
Modernize	25.0%	equip, maintain	12.0%	phones	13.6%
WP, modernize	25.0%	chair	8.0%	WP, more	13.6%
Test equip, mode	12.5%	computer, new	8.0%	furniture	9.1%
Light	6.3%	space	8.0%	noise, printer	9.1%
Light, desk	6.3%	VDT, more	8.0%	test equip, mod	9.1%
Maintain	6.3%	WP, improve	8.0%	tools, improve	9.1%
Maintain, comp	6.3%	color	4.0%	cabinets, elim	4.5%
Printer, moderni	6.3%	computer, place	4.0%	equip, ergon	4.5%
Test equip, more	6.3%	dup mach	4.0%	equip, moderniz	4.5%
		equip, auto	4.0%	IBM for Wang	4.5%
		equip, incr rel	4.0%	test equip, mor	4.5%
		equip, modern	4.0%	test equip, rac	4.5%
		furn, adj	4.0%	VDT, modernize	4.5%
		light	4.0%	VDT, more	4.5%
		partitions	4.0%		
		space, stor	4.0%		
		temp, var	4.0%		
		WP, more	4.0%		
			0.0%		
	100.0%		100.0%		100.0%

Operators

Berlin		Augsburg		Kunia	
Comment	Percent	Comment	Percent	Comment	Percent
Increase reliabi	19.5%	dup mach	37.2%	modernize	39.2%
Modernize	19.5%	computer, place	10.6%	space	7.8%
Maintain	17.1%	color	7.1%	keyboard, adj	5.9%
Systems, speed u	9.8%	test equip, imp	5.3%	organize, ergon	5.9%
Organize, ergono	7.3%	equip, incr rel	3.5%	chair	3.9%
Printer, moderni	4.9%	space, stor	3.5%	equip, elim old	3.9%
Spare parts, inv	4.9%	equip, maintain	2.7%	equip, ergon	3.9%
VDTs, more	4.9%	furn, adj	2.7%	noise	3.9%
Computer, modern	2.4%	keyboard, adj	2.7%	printer, new	3.9%
Data equip, auto	2.4%	equip, des ergo	1.8%	software, updat	3.9%
Light, placement	2.4%	equip, stock sp	1.8%	VDT, modernize	3.9%
Provide authoriz	2.4%	microfiche, imp	1.8%	dirty	2.0%
WP, modernize	2.4%	temp, cold	1.8%	hardware, integ	2.0%
		VDT, improve	1.8%	light, task	2.0%
		chair	0.9%	maintain	2.0%

Operators

Berlin Comment	Percent	Augsburg Comment	Percent	Kunia Comment	Percent
		chair, adj	0.9%	noise, printer	2.0%
		env, dep	0.9%	partitions	2.0%
		env, maintain	0.9%	VDT, color	2.0%
		equip, auto	0.9%		
		equip, calibrat	0.9%		
		equip, org ergo	0.9%		
		equip, too sens	0.9%		
		light	0.9%		
		noise	0.9%		
		privacy	0.9%		
		space, desktop	0.9%		
		space, storage	0.9%		
		tools, improve	0.9%		
		VDT, less	0.9%		
		windows	0.9%		
		workbench	0.9%		
		WP, improve	0.9%		
	0.0%		100.0%		100.0%

Analysts		Analysts		Analysts	
Berlin Comment	%	Augsburg Comment	%	Kunia Comment	%
Modernize	47.1%	copy mach.	36.1%	furniture	18.6%
Computer, modern	11.8%	furniture	8.3%	VDT, more	11.6%
Increase reliabil.	11.8%	space, desktop	8.3%	chair	9.3%
Systems, speed up	11.8%	color	5.6%	modernize	7.0%
Organize, ergonom.	5.9%	computer, place	5.6%	storage, file	7.0%
Provide authoriz	5.9%	space, storage	5.6%	space	4.7%
VDTs, more	5.9%	break area, smo	2.8%	VDT, color	4.7%
		computer, maint	2.8%	VDT, modernize	4.7%
		computer, new	2.8%	carpet	2.3%
		env control, lt	2.8%	color	2.3%
		equip, incr rel	2.8%	CPU, modernize	2.3%
		NDT, black & wh	2.8%	CPU in office	2.3%
		space	2.8%	data storage	2.3%
		space, stor	2.8%	dirty	2.3%
		tel, more	2.8%	equip, accessib	2.3%
		VDT, new	2.8%	equip, excellen	2.3%
		View, sim	2.8%	equip, standard	2.3%
				keyboard, adj	2.3%
				noise, printer	2.3%
				partitions	2.3%
				printer, access.	2.3%
				printer, control	2.3%
	100.0%		100.0%		100.0%

issue was that of copying machine reliability and accessibility,as well as the need for new computers and VDT's. The need for more space and better furniture was also raised. At Kunia, the major equipment issues actually related to improving the physical workspace with 58% of the comments relating to furniture, space, chairs, and cleaning. Other comments related to the need for more VDT's, more modern equipment and accessible printers.

4.3 Suggestions for Workspace Changes

Two separate questions related to the need for changes in the workspace. The first question was not open-ended but rather asked people to select the four changes that they would most like to have made to their overall work environment from a list of 16 possible changes. These data are presented in figures 93-96 and discussed in section 3.8. The second question, which was open-ended, asked people to list any changes that they would make to their work space.

Table 3 presents the data for the open-ended question about desired changes to the workspace. This table indicates that for administrators at all sites, the most desired change is more space for work and for storage. Privacy, better furniture, and task lights were also important issues. People at Kunia raised the issue of the need for conference rooms and more phones. The need for more space (including greater privacy) was also raised by operators at all three sites, with operators at Augsburg mentioning the need for storage space, better organized space, and space for writing at their station. Operators at Berlin and Augsburg mentioned the need for more modern equipment and computers as well as for better lighting and chairs. Operators in Augsburg also mentioned the cold temperatures, need for a conference room, feelings of being confined and a desire to personalize their space. At Kunia, better lighting and chairs were major issues, as well as the lack of maintenance to the workspace and the need for break areas for non-smokers. Finally, analysts also raised the need for more working and storage space, as well as for better organization of the space available. Analysts also mentioned the need for better lighting and furniture, less noise, and greater privacy. Those at Kunia commented on the need for better air quality and more partitions, as well.

Table 3. Desired Changes to Space Question 27

Administrative, Clerical, Other

Berlin Comment	Percent	Augsburg Comment	Percent	Kunia Comment	Percent
space	20.0%	privacy	15.2%	space	25.0%
privacy	13.3%	furniture	12.1%	phones, more	9.4%
test equip, imp	13.3%	space	12.1%	privacy	9.4%
air circ	6.7%	space, storage	12.1%	color	6.3%
furn, color	6.7%	space, writing	12.1%	light, task	6.3%
furn, wood	6.7%	space, organize	9.1%	space, storage	6.3%
light, task	6.7%	light	6.1%	storage, person	6.3%
noise	6.7%	carpet	3.0%	temp, cold	6.3%
partitions	6.7%	color	3.0%	chair	3.1%
space, organize	6.7%	conf room	3.0%	crowded	3.1%
space, storage	6.7%	env, dep	3.0%	dirty	3.1%
		light, adj	3.0%	get out	3.1%
		phone, accesib	3.0%	space, aisles	3.1%
		windows	3.0%	space, maintain	3.1%
				space, org	3.1%
				view, simulated	3.1%
	100.0%		100.0%		100.0%

Operators		Operators		Operators	
Berlin Comments	%	Augsburg Comments	%	Kunia Comments	%
space, desktop	14.9%	space, storage	14.3%	space	13.4%
equipment, organ	8.5%	space, writing	8.3%	light	10.4%
equipment, relia	8.5%	temp, cold	7.1%	light, less	6.0%
light	8.5%	equip, moderniz	6.0%	space, desktop	6.0%
computer, modern	6.4%	space	6.0%	break area	4.5%
carpet	4.3%	light	4.8%	chair	4.5%
chair	4.3%	chair	3.6%	color	4.5%
dirty	4.3%	conf room	3.6%	furniture	4.5%
furniture	4.3%	furniture	3.6%	space, storage	4.5%
privacy	4.3%	space, equip	3.6%	temp, cold	4.5%
space	4.3%	space, organize	3.6%	chair, adj	3.0%
space, storage	4.3%	carpet	2.4%	dirty	3.0%
temp, var	4.3%	crowded	2.4%	organize, ergon	3.0%
air circ	2.1%	equip, organize	2.4%	paint	3.0%
equipment, moder	2.1%	light, task	2.4%	storage, person	3.0%
furniture, adj	2.1%	organize, ergo	2.4%	clutter	1.5%
go out	2.1%	personalize	2.4%	env, dep	1.5%

Operators Berlin Comments	%	Operators Augsburg Comments	%	Operators Kunia Comments	%
light, adj	2.1%	privacy	2.4%	equip, moderniz	1.5%
light, soft	2.1%	smokings	2.4%	light, adj	1.5%
light, task	2.1%	space, aisle	2.4%	light, daylight	1.5%
paint	2.1%	break area, lar	1.2%	light, glare	1.5%
VDT, improve	2.1%	env, dep	1.2%	light, task	1.5%
		equipment, acce	1.2%	noise	1.5%
		heaters, pers	1.2%	partitions	1.5%
		interruptions	1.2%	phone, accessib	1.5%
		light, less	1.2%	privacy	1.5%
		light, rem fluo	1.2%	space, aisles	1.5%
		move around	1.2%	space, org	1.5%
		paint	1.2%	space, rack	1.5%
		partitions	1.2%	temp, hot	1.5%
		phone, improve	1.2%		
		VDT, more	1.2%		
	100.0%		100.0%		100.0%

Analysts Berlin Comment	%	Analysts Augsburg Comment	%	Analysts Kunia Comment	%
space	12.5%	space	38.5%	space	23.8%
space, storage	12.5%	space, organize	15.4%	space, storage	14.3%
furniture	8.3%	chair	7.7%	air qual	8.3%
light	8.3%	equip, moderniz	7.7%	space, org	8.3%
noise	8.3%	noise	7.7%	partitions	6.0%
privacy	8.3%	partitions	7.7%	privacy	6.0%
temp, cold	8.3%	privacy	7.7%	chair	4.8%
carpet	4.2%	see out	7.7%	light	4.8%
crowded	4.2%			furniture	3.6%
furniture, adj	4.2%			color	2.4%
light, adj	4.2%			noise	2.4%
paint	4.2%			break area	1.2%
phones, relocate	4.2%			chair, adj	1.2%
space, desktop	4.2%			env, dep	1.2%
window	4.2%			get out	1.2%
				light, adj	1.2%
				light, less	1.2%
				paint	1.2%
				phones, more	1.2%
				plants	1.2%
				temp, var	1.2%
				VDT, improve	1.2%
				VDT, more	1.2%
				window	1.2%
	100.0%		100.0%		100.0%

5. Physical Measurement Data

5.1 Background Information

A battery of physical measurements was taken at numerous locations in each field station. These included illuminance, luminance, temperature, humidity, air flow rates, sound levels, and subjective assessments of color, furniture condition, and major noise sources. A limited set of measurements was also taken of the workstations dimensions.

Measures were not taken at every location because of the similarity of conditions within a room. Most operators and analysts were located in large open-plan areas so noise levels at one workstation were the same as those nearby. Generally, the levels throughout the facility were quite uniform. They seldom varied more than four or five dBA from place to place, except near major noise sources such as high speed printers. Consequently, a limited number of locations indicated the likely environmental impact, with questionnaire data supplying subjective information. In addition, the overall ambient levels on the working floor (typically about 60-65 dBA) were well below those that could cause any hearing damage to personnel. Even in the vicinity of major noise sources such as printers or generators, the levels usually did not present any major health problem. However, in several instances, noises were sufficiently loud and intrusive (between 80-85 dBA when a printer was operational) to create a major annoyance.

Temperature and humidity levels likewise were relatively uniform within major areas of the facilities, although they varied from area to area and from time to time. Consequently, a limited number of readings were sufficient to indicate the general working conditions.

The one environmental topic dealt with in substantial detail was lighting. It had been identified as a major problem area which "triggered" the initial investigation. Furthermore, the variability of lighting at all sites elicited many unfavorable comments by people performing a variety of tasks in different locations. The analysis revealed considerable variation in overall light levels, light source position, and task contrast (particularly for VDT's).

5.1.1. Temperature and Humidity Measures

Measurements of temperature, humidity, and air speed were made using a Solomat[3] multi-channel modumeter (2016). The device automatically cycles from temperature to air speed to humidity and back to temperature. A platinum thermohygrometer measured temperature and humidity while a hot wire anemometer was used to measure air speed.

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[3] Brand names are provided for identification purposes only, and do not constitute endorsement by the National Institute of Standards and Technology or the U.S. Army.

Using a stand constructed for the probes of the Solomat, measures were taken at individual workstations by placing the system at typical working positions. The readings recorded were those of the third cycle, to permit the measurements to stabilize. The equipment was calibrated prior to the field visits. (Air speed readings were very variable, depending on location and therefore are not covered in any detail in the report.)

5.1.2 Acoustic Measurements

Acoustic measurements were made with a Quest[1] model 155 precision hand-held sound level meter and a standard 1/2 inch condenser microphone with an OB-145 octave band filter attached. The equipment was calibrated before use at each field station. Ambient sound levels were measured on the dBA scale, slow reading (1000 msec time constant). Octave band analyses were made after the ambient measures. Fast responses (125 msec time constant) were taken when the noise sources were variable, primarily when measuring headset output.

Acoustic measurements were made at workstations and in the vicinity of major noise sources, such as high speed printers, teletypewriters, fans, and blowers.

5.1.3 Illumination Measurements

A hand-held Minolta[1] photometer with a cosine-corrected diffuser and a photopic response filter was used to measure illuminance (the amount of light falling on the work surface). Illuminance was measured at the primary task location - the position where the person normally worked-with the chair occupied. Measurements were made at the center of the working area, where a standard target was positioned. When a VDT was present, illuminance was also measured at the screen and keyboard, with the room lights and monitor in their customary setting. In several cases, additional measures were taken with the room lights altered from their normal setting (either to on or off.)

A portable Minolta[1] luminance meter with a one degree spot size was used to measure luminance (the light reflected from a surface). Measures were taken for a standard target containing white, gray, and black surfaces, the ceiling between luminaires, and for the brightest and darkest surfaces in the field of view. Where a VDT was present, luminance measures were taken at the center, left, right, top, and bottom of the screen as well as of two individual characters. While the spot size of the luminance meter covered the entire character, it also covered a small amount of surrounding screen area, so the measurement includes character and background. This procedure appears appropriate for making relative brightness comparisons of screen characters for different types of equipment and light sources.

Other lighting related data recorded were the type of overhead luminaire and its position relative to the workstation as well as any switching

controls available. The presence, type, illuminance, and luminance of any task lighting were also recorded. Finally, observations were made concerning the presence or absence of visible reflections on the VDT screen.

5.2 Berlin Measurement Data

5.2.1 Lighting Measurements

Data from the battery of measurements made at 61 workstations in the Berlin Field Station are presented in Table 4. The data consist of means and standard deviations for the entire sample, followed by those for operational, analytic, and administrative areas both with and without VDT's. There were 21 work stations without VDT's - 7 administrative, 7 analytical, and 7 operational - and 40 workstations with VDT's - 5 administrative, 9 analytical, and 26 operational.

Inspection of Table 4 reveals that the overall mean illuminance in Berlin was quite low, about 282 lux. Generally speaking workstations with VDT's had lower illuminances (234 lux) than those without VDT's (370 lux). Operators and analysts with VDT's had much lower levels (197 lux and 188 lux) than did administrators with VDT's (572 lux), however.

As a result, mean task luminances were quite low as well, with a mean of 60 cd/m^2 for white tasks, 7.2 cd/m^2 for black tasks, and 20.2 cd/m^2 for grey tasks. This resulted in overall black - white contrasts of 0.90 for the whole sample, 0.91 for those without VDT's and 0.89 for those with VDT's. Grey - white contrasts were 0.68, 0.69 and 0.67 for the same areas. The brightest area in the field of view was always the luminaire, with a mean luminance of 2381 cd/m^2, but a very large range of about 25 cd/m^2 to over 5600 cd/m^2 depending on the position of the light source relative to the workstation. Overall ceiling luminance without the luminaire tended to be quite low, around 30 cd/m^2.

Luminaires were generally louvered with either cool white or warm white fluorescent lamps (often in the same fixture). In administrative and analytical areas, 2 lamps were typically illuminated in a fixture (that often originally used 4 lamps). The operations floor had just been relamped with 4 x 4 crossed lamp fixtures with 2" deep cell parabolic louvers. Generally, only 1 lamp was illuminated, and in several cases this lamp supplied blue light. The blue lamp was used because some operators thought it helped them see better. (Before relamping, a number of operators had placed blue plastic sheets over their luminaires to reduce glare on their VDT screens.) Two areas with blue lamps were measured, and found to have very low illuminances (11 - 17 lux) and low lamp luminances (58 - 264 cd/m^2). The blue lamps also caused white and fluorescent objects to fluoresce, suggesting the presence of significant amounts of ultraviolet light in their spectrum. The very low light

Table 4. Physical Measurement Data from Berlin

ID	Illum-PS lux	Lum-W cd/m^2	Lum-Bk cd/m^2	Lum-G cd/m^2	Contrast B-W	Contrast G-W	Ratio B-W	Ratio G-W
Full Sample N = 62								
Avg	282.2	60.4	7.2	20.2	0.90	0.68	0.90	0.68
Std	270.1	62.7	8.9	22.1	0.05	0.10	0.05	0.10
All Workstations with a VDT				N=40				
Avg	234.6	47.0	5.8	16.2	0.91	0.69	0.91	0.69
Std	247.4	55.8	8.0	20.2	0.06	0.11	0.06	0.11
Admin								
Avg	572.2	150.4	18.0	53.2	0.88	0.65	0.88	0.65
Std	263.7	29.0	7.0	12.7	0.03	0.03	0.03	0.03
Analysis								
Avg	187.8	32.3	3.2	9.1	0.91	0.69	0.91	0.69
Std	104.9	23.3	2.3	8.1	0.04	0.11	0.04	0.11
Operations								
Avg	184.0	30.9	4.2	11.2	0.92	0.70	0.92	0.70
Std	226.9	44.5	7.4	16.1	0.06	0.12	0.06	0.12
All Workstations without a VDT				N=22				
Avg	370.6	84.6	9.8	27.3	0.89	0.67	0.89	0.67
Std	287.6	67.2	9.9	23.6	0.05	0.07	0.05	0.07
Admin								
Avg	676.0	149.0	21.3	54.1	0.86	0.64	0.86	0.64
Std	184.6	49.0	8.2	17.8	0.03	0.02	0.03	0.02
Analysis								
Avg	238.9	68.8	4.6	15.9	0.91	0.70	0.91	0.70
Std	177.9	55.9	3.3	11.6	0.04	0.11	0.04	0.11
Operations								
Avg	196.9	36.0	3.4	12.0	0.91	0.67	0.91	0.67
Std	204.1	35.5	3.8	11.5	0.04	0.04	0.04	0.04
Means for Each Job Category								
Admin	632.75	149.60	19.93	53.71	0.87	0.64	0.87	0.64
Anal	210.19	48.27	3.81	12.07	0.91	0.69	0.91	0.69
Ops	186.82	32.06	4.06	11.34	0.92	0.69	0.92	0.69

Table 4 Continued

ID	Lum-Cel cd/m^2	Lum-Lite cd/m^2	Lum-Dk cd/m^2	VDT Kb lux	VDT-Scrn lux	VDT-C cd/m^2	VDT-L cd/m^2	VDT-R cd/m^2
Full Sample N = 62								
Avg	11.9	2380.7	3.91	244.1	137.3	1.8	1.2	1.1
Std	10.2	1705.5	6.19	266.5	142.5	3.2	2.3	2.5
All Workstations with a VDT								
Avg	9.8	2333.7	3.21	244.1	137.3	1.8	1.2	1.1
Std	9.7	1882.8	6.26	266.5	142.5	3.2	2.3	2.5
Admin								
Avg	28.0	4032.4	10.95	671.0	360.6	8.5	5.5	6.1
Std	6.7	1157.4	4.90	228.3	123.3	3.6	2.8	3.6
Analysis								
Avg	5.1	2204.1	0.77	104.1	71.3	1.0	0.4	0.4
Std	3.1	2014.7	0.72	102.4	51.9	1.3	0.8	0.8
Operations								
Avg	7.8	2028.3	2.52	167.1	90.6	0.7	0.6	0.3
Std	7.4	1763.8	6.45	172.5	93.6	1.6	1.3	0.8
All Workstations without a VDT								
Avg	15.7	2465.8	5.17					
Std	10.1	1321.4	5.86					
Admin								
Avg	25.7	3510.7	9.28					
Std	9.3	917.2	7.01					
Analysis								
Avg	9.3	2222.2	2.41					
Std	5.1	1245.7	1.88					
Operations								
Avg	12.0	1664.4	3.82					
Std	6.4	1025.8	4.89					
Means for Each Job Category								
Admin	26.62	3728.06	9.98	671.00	360.60	8.50	5.52	6.09
Anal	6.94	2212.00	1.49	104.14	71.30	1.00	0.37	0.36
Ops	8.74	1946.17	2.81	167.08	90.59	0.70	0.59	0.28

Table 4 Continued

ID	VDT-T cd/m^2	VDT-B cd/m^2	LRTB Avg	LRTB Std	VDT Ch 1	VDT Ch 2	Char. Avg	Ch 1 C-Con	Ch 2 C-Con
Full Sample N = 62									
Avg	0.9	1.4	1.12	1.12	7.5	6.6	7.05	0.87	0.88
Std	1.8	2.7	2.10	2.10	8.8	9.1	8.69	0.17	0.17
All Workstations with a VDT									
Avg	0.9	1.4	1.12	1.12	7.5	6.6	7.05	0.87	0.88
Std	1.8	2.7	2.10	2.10	8.8	9.1	8.69	0.17	0.17
Admin									
Avg	3.5	6.1	5.32	5.32	23.2	23.9	23.53	0.61	0.54
Std	2.5	2.6	2.18	2.18	10.3	13.2	11.24	0.08	0.32
Analysis									
Avg	0.6	0.4	0.43	0.43	10.2	7.5	8.86	0.91	0.90
Std	1.5	1.0	1.02	1.02	7.7	5.3	6.03	0.09	0.08
Operations									
Avg	0.4	0.7	0.51	0.51	3.3	2.9	3.10	0.91	0.91
Std	1.2	2.1	1.16	1.16	3.0	2.9	2.89	0.16	0.18
All Workstations without a VDT									
Avg									
Std									
Admin									
Avg									
Std									
Analysis									
Avg									
Std									
Operations									
Avg									
Std									
Means for Each Job Category									
Admin	3.55	6.12	5.32	5.32	23.18	23.88	23.53	0.61	0.70
Anal	0.59	0.41	0.43	0.43	10.20	7.53	8.86	0.91	0.90
Ops	0.41	0.75	0.51	0.51	3.33	2.86	3.10	0.91	0.91

Table 4 continued

ID	Ch.AVG C-Con	Ch 1 AVG-Con	Ch 2 AVG-Con	Ch.AVG AVG-Con	SndA Phone	SndB Conv	SndC Printer
Full Sample N = 62							
Avg	0.87	0.93		0.93	2.05	2.71	2.60
Std	0.18	0.11		0.11	0.72	0.67	0.54
All Workstations with a VDT							
Avg	0.87	0.93		0.93	2.04	2.69	2.68
Std	0.18	0.11		0.11	0.79	0.77	0.55
Admin							
Avg	0.62	0.76	0.72	0.77	2.33	3.00	2.00
Std	0.09	0.04	0.17	0.04	0.47	0.00	0.00
Analysis							
Avg	0.91	0.97	0.97	0.97	2.00	2.60	2.60
Std	0.08	0.06	0.05	0.05	0.00	0.49	0.49
Operations							
Avg	0.90	0.95		0.95	2.00	2.67	2.82
Std	0.19	0.10		0.10	0.92	0.88	0.51
All Workstations without a VDT							
Avg					2.07	2.73	2.47
Std					0.57	0.44	0.50
Admin							
Avg					2.20	2.60	2.40
Std					0.75	0.49	0.49
Analysis							
Avg					1.80	2.80	2.20
Std					0.40	0.40	0.40
Operations							
Avg					2.20	2.80	2.80
Std					0.40	0.40	0.40
Means for Each Job Category							
Admin	0.62	0.76	0.72	0.77	2.25	2.75	2.25
Anal	0.91	0.97	0.97	0.97	1.90	2.70	2.40
Ops	0.90	0.95		0.95	2.04	2.70	2.82

Table 4 continued

ID	SndD Equip	SndE Vent	SndF Outside	SndG Music	Temp.	Humid	AirFlow	Noise dBA
Full Sample N = 62								
Avg	2.30	2.60	1.03	2.00	71.16	44.20	-0.15	60.53
Std	0.46	0.49	0.16	1.07	3.20	3.96	11.76	8.03
All Workstations with a VDT								
Avg	2.36	2.68	1.00	2.16	71.91	43.57	1.38	61.71
Std	0.48	0.47	0.00	1.08	3.57	4.40	13.28	8.74
Admin								
Avg	2.00	2.67	1.00	1.00	69.92	49.38	-4.32	52.90
Std	0.00	0.47	0.00	0.00	0.51	1.53	2.88	5.48
Analysis								
Avg	2.40	2.60	1.00	2.40	69.54	44.97	0.81	63.56
Std	0.49	0.49	0.00	1.20	3.62	3.91	11.23	6.29
Operations								
Avg	2.41	2.71	1.00	2.29	73.26	41.76	2.84	63.02
Std	0.49	0.46	0.00	1.02	3.23	3.64	14.95	9.02
All Workstations without a VDT								
Avg	2.20	2.47	1.07	1.73	69.99	45.51	-3.28	58.22
Std	0.40	0.50	0.25	1.00	1.26	2.36	6.71	5.78
Admin								
Avg	2.20	2.40	1.20	1.80	70.56	46.00	-3.21	58.50
Std	0.40	0.49	0.40	0.75	0.82	2.63	5.92	4.45
Analysis								
Avg	2.00	2.20	1.00	2.00	67.88	47.18	-5.30	57.80
Std	0.00	0.40	0.00	1.26	0.39	1.17	1.80	6.01
Operations								
Avg	2.40	2.80	1.00	1.40	69.98	43.53	-1.67	58.25
Std	0.49	0.40	0.00	0.80	0.41	0.99	9.26	6.83
Means for Each Job Category								
Admin	2.13	2.50	1.13	1.50	70.29	47.41	-3.68	56.17
Anal	2.20	2.40	1.00	2.20	68.95	45.76	-1.37	61.50
Ops	2.41	2.73	1.00	2.09	72.58	42.13	1.91	61.96

levels, combined with the possible ultraviolet light hazard, suggest that the use of the blue lamps is not an effective means of lighting the space and controlling glare.

Switching control in the field station was typically by means of an on-off switch for an entire room. As a result, if people wished to reduce illuminance selectively for certain areas only, they had to disable lamps. They had no means of increasing illuminance other than replacing burnt-out lamps.

Additional measurements were taken for areas with VDT's. As can be seen from table 4, mean keyboard illuminance was 244 lux (with 671 lux for admin, 104 lux for analysis, and 167 lux for operations) while mean screen illuminance was 137 lux (360, 71, and 91 lux for the 3 groups, respectively). It is important to note the very low illuminances obtained for analysts, who typically must do both paper and VDT tasks.

The luminance of the VDT screens was measured for 35 workstations for the center, right, left, top, bottom, and two characters of each VDT screens. Average screen luminance was then calculated for the right, left, top, and bottom measures. Contrast could then be determined between the screen character and the average or center screen luminance.

Average screen luminance was slightly lower (1.12 cd/m^2) than center luminance (1.79 cd/m^2), with much higher values (5.32, 8.50 cd/m^2) observed for the few administrative locations with VDT's. Calculations of contrast indicated lower mean contrasts for the administrative areas (0.62 for center, and 0.77 for average) than for analysis (0.91 for center and 0.97 for average) or operations (0.90 for center and 0.95 for average). The difference is understandable when the much higher illuminances measured in the administrative areas were considered (750 versus 190 lux).

These data reinforce the validity of the operators' contention that light levels are too high and cause screen glare. Certainly, at all 3 field stations, operators have modified their lighting by disabling lamps, adding homemade paper diffusers, and where possible, switching off luminaires. The result is lower light levels, but increased contrast on the VDT screen. Other problems arose because luminaires were frequently positioned behind an operator, causing reflections on the screen.

The lighting situation is very difficult for those who do paper tasks in the operational area, however. The illuminances are too low for reading poor quality copies, printouts, pencil, and detailed instruction manuals. Furthermore, in analytical and administrative areas, lowering the light levels is usually not appropriate, because the primary visual tasks involve paper and interaction with personnel. The solution for lighting these areas lies in proper positioning of the light sources relative to the VDT screens, use of better luminaires (designed to control glare on VDT screens), careful selection of light levels, and use of individually controlled task lighting.

5.2.2 Measurements of Temperature, Humidity, and Sound Levels

As noted earlier, a portable instrument was used to measure temperature, humidity and air flow for each work station. Measurements were made in late June with outside temperatures in the upper 60's to low 70's. The mean inside temperature was 70°F, (70 - 73°F for those with VDT's and 68 - 70°F for those without VDT's). The range of temperatures was from 67°F to 79°F, depending on location. Mean humidity was 44% with a range of 36 to 52. Air flow varied from about 6 to 62 cfm, with tremendous variation depending on location.

Another way of examining the temperature data is to look at the variation in temperature in a given space by groups. The following breakdown can be made:

Admin		Analysis		Operational	
Temp	Number	Temp	Number	Temp	Number
57-68	0	57-68	10	57-68	4
69-71	12	69-71	4	69-71	10
71+	0	71+	0	71+	15

This evaluation indicates that the analytical and administrative areas were definitely colder than the operational areas (which were undergoing an upgrade at the time of the measurements). The analytic area was particularly cold with no temperatures within the ASHRAE guidelines for interior temperatures in summer (73-79° F), and most temperatures below the guidelines for winter interior temperatures (68-74.5°F). These data indicate some of the reasons for the complaints about being cold from the analysts and administrators seen in figures 10 and 11. Operators reported, however, that temperatures in the operational area had been much colder before the recent upgrade.

At the same time, noise levels were recorded with a portable sound level meter. Mean sound level for all work stations was 60 dBA, but again there was considerable variability depending on location and number of people in the office. For example, most measurements for the areas without VDT's were made when offices were unoccupied (to minimize disruptions) so that the mean level was very low - about 58 dBA. On the other hand, 3 areas in operations had levels in excess of 80 dBA associated with printers. In particular, one area had a printer whose level was 86 dBA. This printer would be active 25 - 30 times a shift and increased the noise level from 75 dBA to 86 dBA. This area was also characterized by excessive heat levels upon occasion, sometimes over 85°F in summer. Printers were definitely the loudest and most annoying noise source particularly in crowded offices. Several analysts commented, however, that the piped-in classical music was difficult to deal with, because they had a tendency to listen to it, rather than their work. It became a distraction because of its content.

5.2.3 Subjective Assessments

The next series of measures were less precise but were an attempt by the experimenters to quantify aspects of the space such as color, chair comfort, sound sources, and similar characteristics. The number and kind of colors observed as an experimenter examined a workstation were recorded. A total of 172 colors were observed for 54 workstations. White and grey occurred most frequently (about 20% of the time), followed by blue and brown (about 12%), black and orange (about 8%), and then yellow, beige, red and green (at 3 to 5%). The most colorful area was operations because each rack was often brightly colored, although because light levels were quite low, colors did not appear vivid. Wall colors tended to be white, beige, or light blue in the facility. Very little wall or desk personalization was observed for the field station as a whole, although the operators and analysts had almost none.

For people without VDT's, chairs tended to be conventional office chairs, while people with VDT's typically had ergonomic chairs with 5 legs and adjustable seats and backs. Since the operations area had recently been refurbished, many chairs were relatively new although problems with sprung seats, broken or missing arms, and excessive tippiness were observed. Subjective assessments of chair quality were made by the experimenter following the lighting measurements. Chairs were judged to be "good" or "poor", with "poor" chairs suffering from broken arms and backs, tippiness, sprung seats, broken reclining mechanisms and similar defects. Categorizing chairs in this manner revealed that about 72% of the chairs in the administrative and analytical areas were in "good" condition, while only about 50% of the chairs in the operational areas could be considered "good", although most of the problems related to missing or broken arms, rather than sprung seats.

Supplementary task lights were observed in only 2 areas without VDT's and 7 with VDT's. Some equipment racks in operations had supplementary lighting built in, but these were often modified by operators by being painted, taped over or turned off, to decrease illuminance and remove bright spots. Incorporating task lighting into the equipment would have been effective if the light position and brightness could have been controlled more easily. Operators in one area commented that the general lighting had gone out recently, forcing them to rely on the emergency lighting - a 75 watt incandescent spotlight mounted about 6 feet behind the racks. This resulted in minimal screen glare and fewer complaints.

The experimenters also assessed the types and annoyance of noise sources in the offices, using a 4-point rating scale where 1 meant "none", 2 meant "very little", 3 meant "some" and 4 meant "a lot" (See Table 4.) Conversations, printer noise and ventilation hum were the most intrusive sources, while outside noise was never a problem. Telephones, music and general office equipment were rarely overly intrusive.

5.3 Augsburg Measurement Data

Table 5 presents summary measurement data from 79 work stations at the Augsburg field station. Again, the data are categorized by the presence or absence of a VDT and then by occupational category - administrative, analytical, and operational. There were 25 work stations without VDT's- 14 administrative, 6 analytical, and 5 operational - and 54 work stations with VDT's - 8 administrative, 12 analytical, and 34 operational.

5.3.1 Lighting Measurements

Mean illuminances at the primary work surface were quite low throughout, with a mean of 235 lux for those without VDT's and 140 lux for those with VDT's. The administrators without VDT's had the highest mean illuminance, 310 lux, with a range of 62 to 706 lux, followed by the analysts at 150 lux and the operators at 127 lux. Administrators with VDT's had a mean illuminance of 230 lux followed by analysts at 144 lux and operators at 114 lux. Average black and white contrasts ranged from 0.86 to 0.90, while grey and white contrasts ranged from 0.61 to 0.67. The illuminances measured at the Augsburg field station were among the lowest for any field station, and suggest the real potential for problems doing paper tasks in <u>all</u> areas, not just operations.

Luminaires were generally prismatic with either cool white or warm white fluorescent lamps (often in the same fixture). In all areas, 2 lamps were typically illuminated in a fixture (that often originally used 4 lamps). About 19 of the 54 work stations had task lights, usually 15" movable fluorescent lights. Only 4 areas with VDT's had task lights.

Detailed measures of illuminances and luminances were taken for 52 work areas with VDT's. These included illuminance at the keyboard and screen, as well as luminance for the display itself. Screen luminance was measured for the center, top, bottom, right and left sides - to create an average background luminance - and for two characters - which were also averaged. In this way, summary measures of screen contrast could be calculated. This procedure has its deficiencies since the character luminance often included some background luminance, but it provides a means of comparing the relative contrast for VDT's in a given situation.

Examining the lighting measures at areas with VDT's indicates that overall mean illuminance at the keyboard was lower than the primary work location at the workstation. For those with VDT's, mean keyboard illuminance was 96 lux while mean screen illuminance was 59 lux. Operators had mean illuminances of 71 lux at the keyboard and 48 lux at the screen, analysts had 124 and 70 lux, and administrators had 128 and 87 lux, respectively. Screen luminance, at the screen center and averaged for five readings at the screen edge was greater for operators, 2.0 and 2.6 cd/m^2 (center and average) but lower for analysts (1.0 and 0.8 cd/m^2) and administrators (1.6 and 1.5 cd/m^2). Average character luminance followed a slightly different pattern - 5.3 cd/m^2 for

Table 5. Physical Measurement Data from Augsburg

Total Sample

ID	Illum-P lux	Lum-W cd/m^2	Lum-Bk cd/m^2	Lum-G cd/m^2	Contrast B-W	Contrast G-W	Ratio B-W	Ratio G-W
Avg	161.1	34.7	4.8	12.2	0.86	0.63	0.14	0.37
Std	146.6	37.8	5.5	12.6	0.04	0.07	0.04	0.07
All Workstations with VDT				N=54				
Avg	125.1	24.0	3.5	9.1	0.84	0.61	0.14	0.37
Std	121.7	27.9	4.5	10.4	0.04	0.03	0.04	0.03
Admin With VDT				N=8				
Avg	230.5	50.8	6.8	19.2	0.87	0.61	0.13	0.39
Std	215.4	52.1	8.1	18.9	0.05	0.03	0.05	0.03
Analysis With VDT				N=12				
Avg	144.5	30.0	3.9	11.2	0.87	0.63	0.13	0.37
Std	63.3	16.0	2.2	6.2	0.02	0.02	0.02	0.02
Ops With VDT				N=34				
Avg	90.1	15.5	2.4	6.0	0.86	0.62	0.15	0.39
Std	81.2	15.8	3.3	6.2	0.04	0.04	0.04	0.04
All Workstations without VDT's				N=25				
Avg	235.1	58.0	7.7	18.9			0.13	0.35
Std	164.2	45.1	6.4	14.3			0.05	0.12
Admin No VDT				N=14				
Avg	310.2	80.7	10.7	24.8	0.86	0.67	0.14	0.33
Std	178.4	48.1	7.0	16.2	0.05	0.13	0.05	0.13
Anal No Vdt				N=6				
Avg	149.6	31.1	4.0	11.7	0.86	0.61	0.14	0.39
Std	87.9	18.0	2.1	6.5	0.03	0.03	0.06	0.18
Ops No VDT				N=5				
Avg	127.4	26.9	3.5	10.8	0.90	0.65	0.10	0.35
Std	75.7	15.9	2.4	6.8	0.06	0.12	0.06	0.12
Mean Data for Each Job Type								
Admin	281.2	69.8	9.3	22.8	0.86	0.65	0.14	0.35
Analyst	146.2	30.3	3.9	11.4	0.87	0.62	0.13	0.38
Operator	95.2	17.0	2.6	6.6	0.86	0.62	0.14	0.38

Table 5. Continued

ID	Lum-Cel cd/m^2	Lum-Lite cd/m^2	Lum-Dk cd/m^2	VDT Kb lux	VDT-Scrn lux	VDT-C cd/m^2	VDT-L cd/m^2	VDT-R cd/m^2
Total Sample								
Avg	7.3	1829.2	2.4	98.0	60.7	2.6	4.7	3.0
Std	5.6	1563.2	3.4	71.4	39.2	6.2	16.3	9.4
All Workstations with VDT								
Avg	6.1	1486.2	1.9	96.4	58.7	1.7	2.1	1.6
Std	4.5	1222.5	3.3	73.2	39.5	3.9	9.3	6.1
Admin								
Avg	10.4	2472.8	3.2	128.4	87.0	1.6	1.4	1.5
Std	6.3	1505.0	4.8	97.3	63.2	1.5	1.4	1.2
Analysis								
Avg	6.7	1661.3	2.8	123.8	70.5	1.0	0.6	0.6
Std	3.3	792.4	3.5	52.8	23.6	0.5	0.4	0.4
Ops								
Avg	4.8	1192.3	1.3	71.0	48.6	2.0	2.8	2.1
Std	3.6	1137.0	2.6	59.6	34.1	4.9	11.8	7.8
All Workstations without VDT's								
Avg	10.1	2634.5	3.6	124.3	93.2	26.7	71.4	38.8
Std	6.8	1935.9	3.1	11.3	8.8	4.0	15.6	9.5
Admin								
Avg	11.6	3300.7	4.7					
Std	8.2	2369.2	3.8					
Anal								
Avg	9.7	2272.0	2.2					
Std	5.3	1363.0	1.7					
Ops								
Avg	7.2	1470.4	2.9	124.3	93.2	26.7	71.4	38.8
Std	4.0	597.0	1.8	11.3	8.8	4.0	15.6	9.5
Mean Data for Each Job Type								
Admin	11.1	2969.6	4.10	128.40	87.03	1.60	1.40	1.48
Analyst	7.7	1864.9	2.57	123.82	70.49	0.97	0.60	0.63
Operator	5.1	1228.0	1.53	75.73	52.57	3.43	6.88	4.24

Table 5. Continued

Total Sample

ID	VDT-T cd/m^2	VDT-B cd/m^2	LRTB AVG	LRTB STD	VDT Ch 1	VDT Ch 2	Avg Char
Avg	1.2	0.8	4.0	1.1	4.67	5.40	5.13
Std	1.4	0.7	12.8	3.4	3.68	5.27	4.13
All Workstations with VDT							
Avg	1.2	0.8	2.0	0.5	4.67	5.40	5.13
Std	1.4	0.7	7.7	1.6	3.68	5.27	4.13
Admin							
Avg	1.6	1.5	1.5	0.4	6.0	7.5	6.72
Std	1.1	1.2	1.1	0.3	5.2	8.7	6.70
Analysis							
Avg	1.3	0.6	0.8	0.3	3.7	3.8	3.74
Std	1.0	0.2	0.4	0.4	1.5	1.6	1.52
Ops							
Avg	1.1	0.7	2.6	0.6	4.72	5.48	5.27
Std	1.6	0.6	9.8	2.0	3.69	4.80	3.77
All Workstations without VDT's							
Avg			55.1	16.3			
Std			12.5	3.1			
Admin							
Avg							
Std							
Anal							
Avg							
Std							
Ops							
Avg			55.1	16.3			
Std			12.5	3.1			
Mean Data for Each Job Type							
Admin	1.63	1.48	1.50	0.40	5.97	7.46	6.72
Analyst	1.34	0.61	0.79	0.34	3.68	3.81	3.74
Operator	1.12	0.72	5.67	1.54	4.72	5.48	5.27

Table 5. Continued

Total Sample

ID	Ch 1 C.Con.	Ch 2 C.Con.	Ch.AVG C.Con.	Ch 1 AVG C	Ch 2 AVG C	Ch.AVG AVG C	SndA Phon	SndB Conv
Avg	0.73	0.74	0.74	0.79	0.8	0.8	2.1	2.9
Std	0.17	0.17	0.17	0.13	0.1	0.1	0.3	0.3
All Workstations with VDT								
Avg	0.73	0.74	0.76	0.79	0.79	0.79	2.1	2.9
Std	0.17	0.17	0.13	0.13	0.14	0.13	0.3	0.3
Admin								
Avg	0.75	0.75	0.76	0.72	0.69	0.71	2.00	2.80
Std	0.06	0.07	0.06	0.06	0.16	0.10	0.00	0.40
Analysis								
Avg	0.72	0.73	0.73	0.74	0.75	0.75	2.00	2.60
Std	0.13	0.13	0.13	0.18	0.17	0.17	0.00	0.49
Ops								
Avg	0.73	0.74	0.77	0.83	0.83	0.83	2.1	3.0
Std	0.20	0.20	0.14	0.10	0.11	0.10	0.3	0.2
All Workstations without VDT's								
Avg							2.2	3.0
Std							0.4	0.0
Admin								
Avg							2.2	3.0
Std							0.4	0.0
Anal								
Avg							2.0	3.0
Std							1.0	1.5
Ops								
Avg							2.0	3.0
Std							0.0	0.0
Mean Data for Each Job Type								
Admin	0.75	0.75	0.76	0.72	0.69	0.71	2.14	2.93
Analyst	0.72	0.73	0.73	0.74	0.75	0.75	2.00	2.64
Operator	0.75	0.77	0.77	0.83	0.83	0.83	2.12	2.97

Table 5. Continued

Total Sample

ID	SndC Print	SndD Equip	SndE Vent	SndF Outs	SndG Music	Temp.	Humid	AirFlow	BkgrdNoise dBA
Avg	2.8	2.6	2.7	1.0	1.7	69.9	53.2	7.7	61.6
Std	0.6	0.6	0.5	0.0	0.8	2.6	3.7	19.6	9.4
All Workstations with VDT									
Avg	2.8	2.6	2.8	1.0	1.6	70.0	53.4	11.0	61.2
Std	0.4	0.5	0.5	0.0	0.7	2.2	3.8	21.1	8.7
Admin									
Avg	2.60	2.20	2.60	1.00	2.00	70.96	52.50	4.24	61.19
Std	0.49	0.40	0.49	0.00	1.26	2.13	3.23	17.35	7.94
Analysis									
Avg	3.00	2.50	2.60	1.00	1.80	71.18	51.05	17.03	56.09
Std	0.00	0.50	0.49	0.00	0.75	1.84	3.75	22.83	3.87
Ops						68.9			
Avg	2.8	2.7	2.8	1.0	1.5	69.2	54.6	10.4	63.1
Std	0.4	0.5	0.5	0.0	0.6	2.0	3.5	20.6	9.4
All Workstations without VDT's									
Avg	2.8	2.7	2.7	1.0	2.0	69.5	52.5	-3.4	62.7
Std	1.0	0.8	0.5	0.0	1.0	3.5	3.0	3.6	10.9
Admin									
Avg	2.4	2.4	2.6	1.0	1.6	69.5	52.4	-5.0	58.6
Std	1.1	0.7	0.5	0.0	0.8	4.3	3.3	1.2	9.1
Anal									
Avg	4.0	2.0	3.0	1.0	3.0	70.6	50.5	-3.2	73.5
Std	2.0	1.0	1.5	0.5	1.5	0.5	25.3	3.0	13.5
Ops									
Avg	3.3	3.7	3.0	1.0	3.0	69.1	53.8	0.3	69.5
Std	0.5	0.5	0.0	0.0	0.0	1.1	2.3	4.6	6.0
Mean Data for Each Job Type									
Admin	2.50	2.36	2.57	1.00	1.71	70.11	52.43	-0.67	59.63
Analyst	3.09	2.45	2.64	1.00	1.91	71.10	50.97	14.14	58.77
Operator	2.85	2.76	2.82	1.00	1.64	69.22	54.50	9.25	64.14

operators, 3.7 cd/m^2 for analysts and 6.7 cd/m^2 for administrators. Calculations of contrasts were made using the average screen and character luminances. These indicate higher contrast for operators (0.83) than administrators (0.74) or analysts (0.72). As noted earlier in 5.1, the contrast was higher for operators because of the lower lighting levels on the operations floor.

5.3.2 Temperature, Humidity and Noise Measurements

Temperature, relative humidity, and air flow were recorded for most work stations. For the whole field station the mean temperature was 70°F with a relative humidity of 53 percent. The range of temperatures was from 57°F to 76°F, with a mean of 69°F in operation and slightly higher in the administrative and analytical areas.

As in Berlin, the distribution of temperatures in the different areas was tabulated for specific temperature ranges. This analysis reveals the following pattern:

Admin		Analysis		Operational	
Temp	Number	Temp	Number	Temp	Number
57-68	3	57-68	1	57-68	13
69-71	12	69-71	8	69-71	17
71-76	4	71-76	5	71-76	5

Unlike Berlin, all areas of the field station were in a temperature range that is often perceived as uncomfortably cold, with certain areas in operations being even colder.

Air flow varied substantially from about 6.7 to 67.2 depending on location. The mean air flow rate for those without VDT's was about 3.4 cfm with a standard deviation of 3.6, but the mean for those with VDT's was 61.2 cfm with a standard deviation of 8.7. These measures are given to provide the reader with some idea of the presence of high air flow rates (often perceived as drafts), but should not be taken as absolute measures due to the difficulty of measuring a constantly changing air flow. Nonetheless, they do indicate the extent of variability in air flow at the field station. The mean noise level was 61.6 dBA, with a range of 40 to 87 dBA, with 40 being an essentially unoccupied administrative office and 87 dBA occurring for an analytic work station near a printer. Conversations with personnel indicated that this particular printer was very annoying and could be heard all over the analytical work area.

5.3.3 Subjective Assessment

While the physical measures were recorded, the most commonly occurring colors in the space were noted. These included the color of the walls,

panels, desk, chair, carpet, and equipment. In all areas, the most common colors were brown, grey, white, beige, and blue. A total of 174 colors were recorded on 63 work stations, with grey and white occurring about 30% of the time, and other colors occurring less than 10%. Occasionally orange, yellow, and/or red were observed. By far the most common colors were neutral, with dark blue and green often being used as wall colors. This reduced wall reflectance and probably contributed to the overall low light levels.

As in Berlin, subjective assessments of chair quality were made by the experimenter following the lighting measurements. Chairs were judged to be "good" or "poor", with "poor" chairs suffering from broken arms and backs, tippiness, sprung seats, broken reclining mechanisms and similar defects. Categorizing chairs in this manner revealed that about 64% of the chairs in the administrative and analytical areas were in "good" condition, while about 76% of the chairs in the operational areas could be considered "good". At the time of the site visit, some of the equipment in the operational area was being upgraded, with new chairs as well as new furniture.

Major noise sources were evaluated by the experimenter using the rating scale described in 5.2.3. Review of these ratings (shown in table 5) for the field station in indicated conversations and printers were rated as somewhat intrusive, followed by ventilation, while outside noise was never a problem. In analytic areas, printer noise emerged as a problem "a lot", but otherwise the rankings tended to be the same for the field station.

5.4 Kunia Measurement Data

5.4.1 Lighting Measurements

Summary data from the measurements made at 122 workstations at Kunia Field Station are presented in Table 6. Of the 83 locations with VDT's, 13 were administrative, 22 were analytical, and 48 were operational. Of the 39 locations without VDT's, 10 were administrative, 16 were analytical, and 13 were operational. This breakdown does not include measurements from 33 locations given in the initial report by Rubin and Collins (1987).

Table 6. Physical Measurement Data from Kunia

ID		Illum-P Lux	Lum-W cd/m^2	Lum-Bk cd/m^2	Lum-G cd/m^2	Ratio B-W	Ratio G-W	Contrast B-W	Contrast G-W
Total Sample			N=122						
Avg		221.7	50.9	9.9	17.2	0.86	0.67	0.86	0.65
Std		220.2	53.5	24.0	17.9	0.14	0.14	0.15	0.09
All Workstations with VDT's					N=83				
	Avg	158.2	35.5	4.6	12.9	0.89	0.67	0.89	0.64
	Std	169.0	42.0	6.6	16.5	0.09	0.15	0.09	0.08
Admin	W/VDT				N=13				
	Avg	408.9	99.8	15.1	47.5	0.82	0.59	0.82	0.59
	Std	187.3	45.1	10.0	11.1	0.23	0.08	0.23	0.08
Analysis					N=22				
	Avg	276.5	67.2	9.0	25.0	0.87	0.64	0.87	0.62
	Std	177.3	41.6	5.9	16.7	0.02	0.10	0.02	0.04
Operations					N=48				
	Avg	76.9	14.7	1.5	4.3	0.91	0.69	0.90	0.66
	Std	69.1	16.9	1.7	4.3	0.06	0.16	0.05	0.08
All Workstations without VDT's					N=39				
	Avg	368.3	86.3	21.8	25.6	0.81	0.67	0.81	0.67
	Std	252.2	59.8	39.8	17.6	0.21	0.12	0.21	0.12
Admin	No VDT				N=10				
	Avg	496.0	120.0	15.3	42.8	0.88	0.65	0.88	0.65
	Std	171.9	46.0	7.1	18.0	0.02	0.03	0.02	0.03
Analysis	No VDT				N=16				
	Avg	312.7	75.4	10.1	26.6	0.87	0.65	0.87	0.65
	Std	129.3	30.7	5.5	13.0	0.04	0.07	0.04	0.07
Operations	No VDT				N=13				
	Avg	338.5	73.8	41.2	11.2	0.68	0.71	0.68	0.71
	Std	361.0	82.3	64.0	5.9	0.32	0.18	0.68	0.71
Mean Data for Each Job Type									
Admin (23)		452.5	109.9	15.2	44.5	0.85	0.63	0.85	0.63
Analyst (38)		292.6	70.9	9.5	25.7	0.87	0.64	0.87	0.63
Operator (61		123.5	25.2	8.6	5.7	0.87	0.69	0.86	0.67

Table 6 Continued

Total Sample

ID	Lum-Ceil cd/m^2	Lum-Lite cd/m^2	Lum-Dk cd/m^2	VDT Lux	VDT-C cd/m^2	VDT-L cd/m^2	VDT-R cd/m^2	VDT-T cd/m^2
Avg	26.7	1339.8	11.4	141.9	2.4	1.6	1.7	2.1
Std	160.2	1139.4	55.4	162.0	3.2	2.4	2.5	3.4
All Workstations with VDT's								
Avg	31.6	1219.7	12.8	145.1	2.2	1.5	1.6	2.0
Std	184.7	1069.4	62.4	161.8	3.2	2.4	2.4	3.4
Admin								
Avg	6.1	2142.5	36.7	394.5	5.4	4.0	2.9	5.9
Std	5.3	923.1	15.1	162.8	4.4	4.0	2.8	5.8
Analysis								
Avg	102.2	1345.1	35.9	243.2	3.4	2.5	2.9	3.3
Std	359.6	824.9	129.7	153.4	2.9	2.2	2.6	3.0
Operations								
Avg	12.6	1054.9	2.1	70.8	1.2	0.7	0.9	0.8
Std	80.4	1091.3	6.8	85.6	2.3	1.3	2.0	1.8
All Workstations without VDT's								
Avg	12.2	2048.7	6.4	102.2	5.0	2.7	4.0	4.3
Std	8.9	1037.2	9.2	158.6	2.7	1.4	2.2	1.8
Admin								
Avg	9.1	2859.3	39.0	419.6	8.9	4.4	7.2	6.6
Std	4.0	455.2	0.0	0.0	0.0	0.0	0.0	0.0
Analysis								
Avg	17.0	1886.7	6.7					
Std	8.4	689.8	7.2					
Operations								
Avg	4.5	1886.3	1.8	38.7	3.7	2.1	2.9	3.6
Std	4.9	1478.9	2.0	77.5	1.7	1.2	1.3	1.4
Mean Data for Each Job Type								
Admin (23)	7.3	2418.2	36.9	397.0	5.7	4.0	3.2	5.9
Analyst (38)	63.3	1585.8	22.5	243.2	3.4	2.5	2.9	3.3
Operator (61	230.8	1163.3	2.0	67.9	1.3	0.8	1.0	1.0

Table 6 Continued

Total Sample

ID	VDT-B cd/m^2	LRTB AVG	LRTB STD	VDT Ch. cd/m^2	Ch. C-Con	Ch. Avg	Sounds Ringing	Conver.
Avg	1.6	1.75	0.51	9.22	0.75	0.83	1.8	3.0
Std	2.3	2.45	0.95	9.61	0.37	0.25	0.7	0.5
All Workstations with VDT's								
Avg	1.6	1.67	0.50	9.21	0.79	0.85		
Std	2.3	2.45	0.96	9.76	0.21	0.15		
Admin								
Avg	3.6	4.11	1.83	18.03	0.66	0.76		
Std	2.9	3.29	1.88	13.44	0.23	0.11		
Analysis								
Avg	2.7	2.84	0.45	15.33	0.76	0.78		
Std	2.7	2.61	0.40	9.27	0.17	0.17		
Operations								
Avg	0.8	0.80	0.24	5.44	0.82	0.89		
Std	1.3	1.53	0.44	6.19	0.20	0.13		
All Workstations without VDT's								
Avg	3.3	3.57	0.82	9.65	-0.12	0.24	1.9	3.0
Std	1.3	1.57	0.39	5.12	1.26	0.80	0.7	0.4
Admin								
Avg	4.7	5.73	1.20	15.11	0.41	0.62		
Std	0.0	0.00	0.00	0.00	0.00	0.00		
Analysis								
Avg								
Std								
Operations								
Avg	2.8	2.85	0.69	7.83	-0.29	0.12		
Std	1.1	1.10	0.37	4.66	1.41	0.89		
Mean Data for Each Job Type							1.7	3.1
Admin (23)	3.7	4.22	1.79	17.82	0.65	0.75	1.7	2.6
Analyst (38)	2.7	2.84	0.45	15.33	0.76	0.78	2.0	3.1
Operator (61	0.8	0.89	0.26	5.55	0.77	0.86	1.7	3.0

Table 6 Continued

Total Sample

ID	Sounds Print	Equip	Vent	Outside	Music	Temp.	Humid.	Air Flow	Ambient Noise
Avg	2.7	2.6	3.2	1.0	1.0	73.3	58.8	1.8	75.6
Std	0.6	0.6	0.8	0.0	0.0	1.5	5.3	7.2	3.9
All Workstations with VDT's									
Avg									
Std									
Admin									
Avg									
Std									
Analysis									
Avg						73.3	62.9	2.1	
Std						1.4	3.9	10.7	
Operations									
Avg						73.1	55.6	2.3	75.6
Std						1.5	3.3	5.1	2.1
All Workstations without VDT's									
Avg	2.6	2.5	3.0	1.0	1.0	73.6	61.9	0.9	77.4
Std	0.7	0.6	0.8	0.0	0.0	1.4	5.2	7.8	5.8
Admin									
Avg									
Std									
Analysis									
Avg						73.6	63.8	1.5	74.8
Std						1.3	3.8	8.5	4.5
Operations									
Avg						73.7	54.4	1.5	84.0
Std						1.8	2.7	2.7	2.0
Mean Data fo	2.8	2.7	3.3	1.0	1.0	73.2	57.4	2.2	74.9
Admin (23)	2.4	2.3	2.4	1.0	1.0				
Analyst (38)	2.7	2.5	2.7	1.0	1.0	73.5	63.4	1.7	73.4
Operator (61	2.8	2.8	3.6	1.0	1.0	73.2	55.5	1.9	76.5

Inspection of Table 6 reveals a familiar pattern of results. Overall mean illuminance is greatest for administrative workstations without VDT's (496 lux), and least for operational locations with VDT's (77 lux). Analytical areas were in between with 276 lux for those with VDT's and 313 lux for those without. Operational areas had a mean illuminance of 76.9 lux for areas with VDT's and 338.5 lux for areas without VDT's. The high illuminances for the latter is due to two drafting locations with illuminances of 1100 lux. Without these two areas, the mean illuminance for operational areas without VDT's was about 195 lux. The mean illuminance for the site was 222 lux, similar to other field stations, but quite low by IESNA guidelines for offices where detailed or low contrast tasks are done.

The pattern of mean luminance for white paper follows that for mean illuminance and varies from a low of 15 cd/m^2 for operational areas with VDT's to a high of 120 cd/m^2 for administrative areas without VDT's. Black and white contrasts varied from .68 to .90 for these same areas. Ceiling luminances were generally low (about 10 cd/m^2), while the mean luminance of all light sources was about 1300 cd/m^2 but that for administrative areas was much higher - about 2400 cd/m^2.

Measurements of illuminance at the keyboard and screen for locations with VDT's confirmed that this measure was quite low. A mean of 71 lux occurred for screens in operational areas, while means of 243 and 395 lux were found for screens in analytical and administrative areas. The average screen luminance was 4.1 cd/m^2 for administrative areas, 2.8 cd/m^2 for analytical areas, and 0.8 cd/m^2 for operational areas. Luminance at the screen center was 5.4 cd/m^2, 3.4 cd/m^2, and 1.2 cd/m^2 for the same areas. Average luminance in the same areas for screen characters was 18.0 cd/m^2, 15.3 cd/m^2, and 5.4 cd/m^2. This resulted in calculated contrasts of 0.76 0.78, and 0.89 for administrative, analytical and operational areas. These findings suggest that the higher illuminances in the administrative areas reduce VDT screen contrast. This was borne out by the many clerical personnel who had added homemade shields to screens, or bought screens designed to reduce glare on VDT's. In operational areas personnel deliberately reduced the illuminance itself. In the earlier report by Rubin and Collins (1987), measurements with and without the room lights in operations indicated that screen contrast was higher with reduced room light levels.

Luminaires at the site were quite mixed, with troffered louvers in most administrative areas, prismatic louvers in analytical areas, and troffered louvers in operational areas. In a few cases, deep cell parabolic louvers had been added to minimize screen glare. In administrative and analytic areas, 2 lamps were typically illuminated in a fixture (some were originally 4 lamp fixtures), while in operations only 1 lamp (if any) would be illuminated. Reflections from the overhead lights were visible in about half the workstations.

5.4.2 Measurements of Temperature, Humidity, and Sound Levels

The same instrument used in Berlin and Augsburg was also used at Kunia to measure temperature, humidity and air flow at selected (about 28) work stations. Measurements were made in April with outside temperatures in the upper 70's to low 80's. The mean temperature for the field station was 73.5°F, with a mean relative humidity of about 58%. As noted in the companion report, fewer complaints were made about cold temperatures at Kunia; the interior temperature was higher. Measured temperatures reported in the earlier report were lower - typically between 66 and 71° F, and mean relative humidities of 68-63%. These measures had been taken in December, which may account for the lower interior temperatures. Individual areas at Kunia were sometimes too warm (the warmest temperature, 75°, was observed in analysis) or too cold (the coldest temperature, 69° was observed in operations), but not to the extent seen at the other stations visited. Relative humidities were often higher, however, the mean for analysis being 63%. Mean noise levels were quite high - around 76 dBA for the field station, with 77 dbA for those without VDT's and 75 dBA for those with VDT's. These averages included four printers in excess of 81 dBA (range 81-86 dBA).

5.4.3. Subjective Assessments

The next series of measures involved the experimenter's subjective assessment of aspects of the station such as chair comfort, color, sound sources and degree of annoyance. The first issue was the number and variety of colors within the workstations. Again, the experimenter looked around the space and recorded the major colors of furnishings, walls, and equipment. A total of 263 colors was observed for 94 workstations. As at Augsburg, there were very few bright colors. The most frequently occurring color was gray for 24% of the sample followed by white, brown, beige and blue (18%, 16%, 13%, and 10%). The frequencies for green, black, and yellow were all less than 6%, with red and orange occurring less than 1% of the time. Unlike Berlin, the operations area did not have brightly colored equipment racks; rather the dominant colors were gray, white, and blue or black. Administrative areas tended to be furnished in browns and beiges with wood furniture, while analytic areas had a great deal of gray metal furniture and carpets in very poor condition. There was greater desk personalization such as pictures or cartoons in administrative and analytic areas, but only limited use of either in operations. In analysis and operations, the walls had little personalization (other than working aids), while in administrative areas some pictures were observed on the walls.

Chair color varied greatly with a number of red green, orange, and blue chairs found in operations, but relatively few "ergonomic" chairs. Again, subjective assessments were made of chair condition when the experimenter sat to take lighting measurements. This assessment indicated about that 70% of the chairs in both administration and analysis were in "good" condition, but only about 20% of those in

operations. Of course, the chairs in operations receive 24 hour a day use with 3 different people using a chair each day. Many chairs in operations were wobbly, had broken backs and/or arms, or did not recline properly (these latter would throw one out of the chair if one leaned back too far).

A subjective analysis of the kinds and bothersomeness of sounds in the individual workstation was also made. This analysis suggested that ventilation noise and conversations were the most intrusive types of sounds followed by printers and equipment. Outside noise and music were not a problem at the time the assessments were made.

6. Conclusions

The detailed analysis of the questionnaire and measurement data confirms that the physical conditions at the three field stations were less than ideal for those who work in them. Almost every physical measure is at or below the lower limit of acceptability for good design.

For example, for lighting, the IESNA (1987) recommends levels of 500 to 1000 lux for performing tasks of medium contrast (such as a #3 pencil or a printout with a poor ribbon), and levels of 200 to 500 lux for tasks of high contrast (such as printed or typed copy). Yet, mean illuminances for all sites were below 300 lux and below 160 lux at Augsburg. Even the administrative areas at Augsburg were only about 350 lux. These data suggest that people performing difficult visual tasks (including pencil tasks) are likely to find the light levels somewhat inadequate.

The lighting problem is complicated, however, because of the widespread use of VDT-type screens. Here, reflections from the light sources obscure characters on the screen, while high light levels tend to reduce the contrast between character and background. Correcting these problems requires careful positioning of the light source relative to the task, use of specialized luminaires to direct the light down rather than out, and, in some areas, use of lower light levels (the IESNA recommends 50 to 100 lux for exclusively VDT-type tasks). Resolving the conflicting goals of lighting for mixed visual tasks such as both VDT's and paper tasks requires careful attention to the placement of both the working surfaces and the light sources, and the use of flexible task lighting for paper tasks.

Temperature and humidity measures were another area in which conditions tended to be at the lower range of the acceptability criteria. Thus, according to the thermal comfort standards used in the U.S. (ASHRAE Standard 55-1981), "80% of all adults dressed for winter indoor conditions find temperatures acceptable between 68 °F and 74.5° F (20-23.5 °C), a relative humidity of 30-60%, and the air velocity at 0.15-0.25 m/sec. Acceptable summer indoor temperature is between 73 and 79 °F (20-26.5 °C)." Meyer (1983, p.27) pointed out that "extensive experimentation has shown that for an average, sedentary, lightly clothed person, this [thermal comfort] occurs most readily when the air in a standard room has a temperature of 24.5 °C (76.1 °F), a relative humidity of 40%, and an air velocity of 0.25 m/sec".

As with lighting, temperatures at the site tended to be outside the guidelines for comfort. Most temperatures were cold enough to be uncomfortable for a person seated for long hours, and some were cold enough to require additional clothing such as field jackets and gloves. The cold temperatures are combined with high air flow rates on the operations floor, thus adding to the occupants' discomfort.

The measured noise levels did not indicate any likely health problem but did suggest another area of environmental annoyance. Some printers at all three sites were unacceptably loud and should be shielded, moved, or replaced. The major noise problems, however, relate to conversations and job-related noise (such as training films, meetings, etc.) which occurred in the workspaces. These were most noticeable in the analytic areas which were invariably crowded open-plan spaces where people need to concentrate but also interact with other analysts. This noise adds distractions and combines with the other environmental problems to create an annoying work environment.

The condition of the furniture, chairs, and carpets, the lack of storage and conference space, the use of generally drab colors, and the lack of windows or access to the outside combine with the more quantifiable environmental problems to make a less than pleasant work environment and contribute to occupant stress. While proving that the work environment decreases productivity is not easily done, the authors believe that the conditions in the field stations are such as to decrease productivity, particularly when the equipment problems are also considered. The companion report (Rubin and Collins, 1988) provides suggestions for ameliorating some of the environmental conditions in the field stations.

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Appendix A

Questionnaire

Location_____ 6-17-87

ENVIRONMENT QUESTIONNAIRE

1. How long have you worked in the facility where you are now employed?

____ Less than 3 months
____ 3-6 months
____ 6-12 months
____ 1-2 years
____ More than 2 years

2. How long have you worked at your present job in this facility?

____ Less than 3 months
____ 3-6 months
____ 6-12 months
____ 1-2 years
____ More than 2 years

3. How long have you worked in facilities such as this before your present assignment?

____ Less than 1 year
____ 1-4 years
____ 5-8 years
____ 9-15 years
____ More than 15 years

4. For each of the following spaces in your facility, please rate the quality of the lighting by placing an x in the appropriate columm.

	Excellent	Pretty Good	Neutral	Not Very Good	Poor
MP's Station	_____	_____	_____	_____	_____
Break Areas	_____	_____	_____	_____	_____
Corridors & Hallways	_____	_____	_____	_____	_____
Restrooms	_____	_____	_____	_____	_____
Work Spaces	_____	_____	_____	_____	_____

Dining Facility	_____	_____	_____	_____	_____
Snack Bar	_____	_____	_____	_____	_____

5. Please rate your work space on each of the following:

	Excellent	Good	Fair	Poor
Amount of Space Available to You	_____	_____	_____	_____
Quality of Desks and Chairs	_____	_____	_____	_____
Amount of Lighting	_____	_____	_____	_____
Location of Ceiling Lights for Your Task	_____	_____	_____	_____
Color of Walls and Partitions	_____	_____	_____	_____
Color of Furniture	_____	_____	_____	_____
Storage Space	_____	_____	_____	_____
Conversational Privacy	_____	_____	_____	_____
Access to Co-workers	_____	_____	_____	_____
Wall/Desk Space for Personal Items	_____	_____	_____	_____
Condition of Furniture	_____	_____	_____	_____
Ability to Adjust Light for the Work Station	_____	_____	_____	_____
Visual Privacy	_____	_____	_____	_____
Amount of Surface Area for Work	_____	_____	_____	_____
Comfort of Chair	_____	_____	_____	_____
Ventilation and Air Circulation	_____	_____	_____	_____
Heating	_____	_____	_____	_____
Cooling	_____	_____	_____	_____

Air Quality _____ _____ _____ _____

6. The way offices and other work spaces are arranged in terms of making it easier for employees to get their jobs done is:

____ Excellent
____ Pretty Good
____ Fair
____ Poor

7. The way the work spaces and offices look is:

____ Excellent
____ Pretty Good
____ Fair
____ Poor

8. On the average, how many hours a day do you spend at your work space in this facility?

1-2 Hours	3-4 Hours	5-6 Hours	7-8 Hours	9-10 Hours	More than 10 hours
____	____	____	____	____	____

9. Which of the following tasks <u>best</u> describes the work that you normally do. (CHECK THOSE THAT APPLY)

_____ Transcribing taped material
_____ Collecting or recording material
_____ Using a video display terminal (VDT)
_____ Reading and writing
_____ Analysis of material
_____ Filing
_____ Attending meetings
_____ Talking on telephone
_____ Maintaining equipment
_____ Installing equipment
_____ Managing
_____ Supervising operational activities
_____ Communicating (message traffic)
_____ Other. Please specify _____

10. Please estimate the number of hours that you spend at each task on a typical day.

	Rarely	Less than 2 hours	2-4 hours	4-6 hours	6-8 hours	More than 8 hours
Reading	_____	_____	_____	_____	_____	_____
Listening	_____	_____	_____	_____	_____	_____
Transcribing	_____	_____	_____	_____	_____	_____
Using VDT	_____	_____	_____	_____	_____	_____
Filing	_____	_____	_____	_____	_____	_____
Analysis	_____	_____	_____	_____	_____	_____
Other	_____	_____	_____	_____	_____	_____

11. For each task performed, please rate the lighting available to you.

	Excellent	Pretty Good	Neutral	Not Very Good	Poor	Not Applicable
Reading	_____	_____	_____	_____	_____	_____
Transcribing	_____	_____	_____	_____	_____	_____
Using VDT	_____	_____	_____	_____	_____	_____
Filing	_____	_____	_____	_____	_____	_____
Analysis	_____	_____	_____	_____	_____	_____
Other	_____	_____	_____	_____	_____	_____

12. How would you describe the amount of light available to you now?

_____ Much too bright
_____ A bit too bright
_____ Just about right
_____ A bit too dim
_____ Much too dim

13. Overall, how satisfied are you with the lighting at your work space.

_____ Very Satisfied
_____ Fairly Satisfied
_____ Neither Satisfied nor Dissatisfied
_____ Not Very Satisfied
_____ Not At All Satisfied

14. Are there any changes that you would make to the lighting at your workstation?

_____
_____
_____
_____

15. If you use a Video Display Terminal (VDT), indicate how bothersome each of the following conditions is for you. If you do not use a VDT, please go to question 16.

	Not at all Bothersome	Not very Bothersome	Fairly Bothersome	Very Bothersome
Screen Flicker	_____	_____	_____	_____
Distance to Screen	_____	_____	_____	_____
Screen Angle	_____	_____	_____	_____
Glare from Overhead Light	_____	_____	_____	_____
Letter Size	_____	_____	_____	_____
Distance to Keyboard	_____	_____	_____	_____
Keyboard Angle	_____	_____	_____	_____
Height of Desk	_____	_____	_____	_____
Chair	_____	_____	_____	_____
Brightness of Screen	_____	_____	_____	_____
Ease of Reading Printed/Typed Material	_____	_____	_____	_____
Brightness of Overhead Light	_____	_____	_____	_____
Ease of Reading Screen Characters	_____	_____	_____	_____
Inability to Adjust Screen or Keyboard	_____	_____	_____	_____
Space for Printed Material	_____	_____	_____	_____

16. For printed or written tasks, indicate how bothersome each of the following conditions is for you.

	Not at all Bothersome	Not very Bothersome	Fairly Bothersome	Very Bothersome
Glare from Overhead Light	_____	_____	_____	_____
Dimness of Overhead Light	_____	_____	_____	_____
Height of Desk	_____	_____	_____	_____
Chair	_____	_____	_____	_____
Ease of Reading Printed/Typed Material	_____	_____	_____	_____
Brightness of Overhead Light	_____	_____	_____	_____
Room to Spread Out Paper Task	_____	_____	_____	_____
Quality of Printed Material	_____	_____	_____	_____

17. Sometimes the arrangements of work stations can be distracting to the people in offices. Please indicate how bothersome each of the following is to you.

	Not at all Bothersome	Not very Bothersome	Fairly Bothersome	Very Bothersome
Ringing Telephones	_____	_____	_____	_____
Conversation of People	_____	_____	_____	_____
Noise From Printers	_____	_____	_____	_____
Noise From Other Equipment	_____	_____	_____	_____
Noise From Ventilating System	_____	_____	_____	_____
Noise From Corridors	_____	_____	_____	_____
Reflected Glare Off Work Surfaces	_____	_____	_____	_____

	Not at all Bothersome	Not very Bothersome	Fairly Bothersome	Very Bothersome
Glare From Ceiling Lights	_____	_____	_____	_____
Overly Dim Lights	_____	_____	_____	_____
Absence of View or Simulated View	_____	_____	_____	_____
Too Hot On Days	_____	_____	_____	_____
Too Cold On Days	_____	_____	_____	_____
Too Hot On Mids	_____	_____	_____	_____
Too Cold On Mids	_____	_____	_____	_____
Too Many Drafts	_____	_____	_____	_____
Air is Too Stuffy	_____	_____	_____	_____
People Walking Around	_____	_____	_____	_____
People Too Close	_____	_____	_____	_____
People Too Far Apart	_____	_____	_____	_____

18. Please rate each of the following by placing an X in the space that best describes your feelings about this facility. For example, if you think the facility is pleasant, put an X next to the word "pleasant"; if you think it is unpleasant, put an X next to the word "unpleasant"; and if you think it is in between, please put an X where you think it belongs.

Adequate for my job	____	____	____	____	____	Not adequate to do job
Pleasant	____	____	____	____	____	Unpleasant
Well Maintained Interiors	____	____	____	____	____	Poorly Maintained Interiors
Confined	____	____	____	____	____	Spacious
Stimulating Spaces	____	____	____	____	____	Unstimulating Spaces
Difficult to Find Way Around	____	____	____	____	____	Easy to Find Way Around
Poorly Lit Spaces	____	____	____	____	____	Well Lit Spaces
Humid	____	____	____	____	____	Dry
Clean	____	____	____	____	____	Dirty
Noisy	____	____	____	____	____	Quiet
Colorful	____	____	____	____	____	Drab
Interesting	____	____	____	____	____	Boring
Hot	____	____	____	____	____	Cold
Relaxed Atmosphere	____	____	____	____	____	Tense Atmosphere

Soft Lighting	____	____	____	____	____	Harsh Lighting
Bright	____	____	____	____	____	Dim
Better Than Other Field Units	____	____	____	____	____	Worse Than Other Field Units

19. How often have you experienced any of the following symptoms which you think are caused by working in this facility?

	Never	Rarely	Sometimes	Always
Headache	_____	_____	_____	_____
Dizziness	_____	_____	_____	_____
Sleepiness	_____	_____	_____	_____
Sore Throat	_____	_____	_____	_____
Runny Nose	_____	_____	_____	_____
Irritated Eye	_____	_____	_____	_____
Trouble Focusing Eyes	_____	_____	_____	_____
Difficulty in Concentrating	_____	_____	_____	_____
Leg Going to Sleep or Cramping	_____	_____	_____	_____
Fatigue	_____	_____	_____	_____
Ear Infection	_____	_____	_____	_____
Frequent Colds	_____	_____	_____	_____
Sinus Problems	_____	_____	_____	_____
Allergies	_____	_____	_____	_____

20. How many days have you been absent from work due to illness during the last six months?

_____ None
_____ 1-2 days
_____ 3-5 days
_____ 6-12 days
_____ More than 12 days

21. Overall, how satisfied are you with your work equipment?

_____ Very Satisfied
_____ Fairly Satisfied
_____ Neither Satisfied Nor Dissatisfied
_____ Not Very Satisfied
_____ Not at all Satisfied

22. If you could make any changes to your work equipment, what would you do?__
_____
_____
_____

23. Do you feel the need to have a view outside during break periods or lunch?

_____Yes _____No

24. Suppose you could make 4 changes to your overall work environment. Using the list below, indicate the 4 changes you would make in order of preference (where 1 = most preferred).

_____ A. A better year-round temperature
_____ B. More privacy
_____ C. Access to the outside during lunch and breaks
_____ D. Change in color of walls, furnishings or carpets
_____ E. Improved lighting
_____ F. Less noise
_____ G. Improved air circulation
_____ H. Move further away from co-workers
_____ I. More comfortable chair
_____ J. Better break areas
_____ K. More comfortable furnishings
_____ L. More frequent cleaning
_____ M. Adjustable task lighting
_____ N. More adjustable chair
_____ O. Simulated view out/daylight
_____ P. Other_____

25. Please explain the reasons for your four choices.

1._____
_____
2._____
_____
3._____
_____
4._____
_____

26. Overall, how satisfied are you with your work space?

_____ Very Satisfied
_____ Fairly Satisfied
_____ Neither Satisfied nor Dissatisfied
_____ Not Very Satisfied
_____ Not At All Satisfied

27. If you could make any changes to the work space, what would you do?_____
_____
_____
_____
_____

28. Overall, how satisfied are you with your work schedule?

_____ Very Satisfied
_____ Fairly Satisfied
_____ Neither Satisfied nor Dissatisfied
_____ Not Very Satisfied
_____ Not At All Satisfied

29. If you could make any changes to your work schedule, what would they be?____
_____
_____
_____

30. Please indicate how true the following statements are for your job.

	Very True	Somewhat True	Not Very True	Not At All True
The work is important	_____	_____	_____	_____
When I talk to co-workers, others can hear us	_____	_____	_____	_____
My job is satisfying	_____	_____	_____	_____
My work must be very accurate	_____	_____	_____	_____
I have all the equipment to get my job done well	_____	_____	_____	_____
My eyes get tired when I work for more than 2 hours	_____	_____	_____	_____
My job requires me to stay in one place all day	_____	_____	_____	_____
My job requires a great deal of concentration	_____	_____	_____	_____
I have enough time to get my work done	_____	_____	_____	_____
Lighting at my desk keeps me from doing my job well	_____	_____	_____	_____
I have opportunities to develop my own special abilities	_____	_____	_____	_____
I am satisfied with the quality of my work	_____	_____	_____	_____
I miss having a view out or simulated window	_____	_____	_____	_____
Others get better				

furniture	_____	_____	_____	_____
I need more time on a terminal	_____	_____	_____	_____
Noise keeps me from doing my job well	_____	_____	_____	_____
My job requires me to work very fast and accurately	_____	_____	_____	_____
I would like to know what the weather is like outside	_____	_____	_____	_____

31. Please rate your chair on each of the following:

	Excellent	Good	Fair	Poor
Ease of movement on carpet	_____	_____	_____	_____
Ease of adjusting seat height	_____	_____	_____	_____
Ease of adjusting back height	_____	_____	_____	_____
Seat tilt/tension	_____	_____	_____	_____
Back tilt/tension	_____	_____	_____	_____
General condition	_____	_____	_____	_____

32. Which of the following <u>best</u> describes your job?

_____ Administrative
_____ Clerical
_____ Operations
_____ Analyst
_____ Other

33. Are you Military Personnel? Yes_____ No_____
Civilian? Yes_____ No_____
Contractor? Yes_____ No_____

34. If you are military, which service do you belong to?_____

35. If you are military, are you? Enlisted_____
NCO_____
Officer_____

36. Are you a female? _____
male? _____

37. Do you wear glasses? Yes_____ No_____
contact lenses? Yes_____ No_____
bifocals? Yes_____ No_____

38. If you answered yes to question #37, how long have you worn corrective lenses?

_____ Less than 6 months
_____ 6-12 months
_____ 1-2 years
_____ 2-5 years
_____ More than 5 years

39. How old are you?

_____ Under 20 _____ 20-25 _____ 25-30

_____ 30-35 _____ 35-44 _____ 45 or over

40. Today is:

_____ Monday _____ Tuesday _____ Wednesday _____ Thursday

_____ Friday _____ Saturday _____Sunday

41. What shift are you currently working?

Days_____
Swings_____
Mids_____

Thank you very much for your participation.

Environmental Measures - Direct

Time is: _____ Date is: _____ Space I.D. _____

Recorder: _____

1. Number of work surfaces or places where tasks occur: _____1 _____2 _____3 or more

1a. Illuminance at PRIMARY task surface while SEATED in chair:

_____lux

1b. Illuminance at PRIMARY task surface while chair UNOCCUPIED:
_____lux

1d. Luminance at PRIMARY task area:

_____ fL WHITE PAPER _____ fL BLACK TASK

_____ fL GREY TASK

_____ fL CEILING BETWEEN LUMINAIRES

_____ fL BRIGHTEST LIGHT SOURCE IN FIELD

_____ fL DARKEST AREA IN FIELD OF VIEW

2. Overhead Luminaire
Lens_____
Grille/Louvre_____ None_____
_____ Other_____
_____
Watts_____

3. Position with respect to work station:

Above_____ Ahead_____
____Right_____ Left_____
Behind_____

4. Lamp Type for overhead lighting

Fluor._____ CW_____ WW_____ Daylight_____ Other_____
Incandescent_____ Number of tubes _____
Dimming_____

5. Control of Switching

None _____

On-Off_____ Multiple Levels _____

6. Have lamps been switched off?

_____Yes _____ How Many? _____No

7. Does the workstation have a VDT?..... ____Yes ____No

Type of VDT _____

a. Reflected light from electric light sources can be seen on screen?..... ____Yes ____No

b. Keyboard can be raised and lowered?.. ____Yes ____No

c. Screen can be raised, lowered, or tilted?..... ____Yes ____No

d. Location of screen_____

e. Monochrome _____ Color _____

f. Screen Resolution: Good _____

Average _____

Poor _____

8. Lighting at VDT task area:

a. Illuminance on Keyboard with room lights _____ lux

without room lights _____ lux

b. Illuminance on Screen with room lights _____ lux

without room lights _____ lux

c. Luminance in FtL

_____	fL CENTER	_____	fL CENTER
_____	fL LEFT EDGE	_____	fL LEFT EDGE
_____	fL RIGHT EDGE	_____	fL RIGHT EDGE
_____	fL UPPER EDGE	_____	fL UPPER EDGE
_____	fL LOWER EDGE	_____	fL LOWER EDGE
_____	fL SCREEN CH	_____	fL SCREEN CH
_____	fL SCREEN CH	_____	fL SCREEN CH
_____	Character	_____	Character

11. Dominant colors in workstation: _____ _____

_____ _____ _____

12. Workstation is in an open area:

12a. Type of panels: 1. 42"-54" Panels _____
2. 60"-64" Panels _____
3. 68"-74" Panels _____
4. Open without Panels _____
5. Other: (Specify)_____

____12b. The space containing the workstation is:
1. Private _____
2. Shared _____

13. Furnishings are predominantly (Check all that apply):

Wood _____
Metal _____
Fabric _____
Other (Specify) _____
_____ CONDITION

14. Walls are predominantly (Check all that apply):

Wood _____
Metal _____
Fabric _____
Dry Wall or Plaster _____
Brick or Block _____
Demountable Ceiling Height Partitions _____
Vinyl Wallcovering _____
Glass _____
Other (Specify) _____

15. Type of office chair:
Arms _____ Number of legs_____
Wheels_____ Colors_____
Adjustable back_____ Adjust. Seat_____
Executive_____ Secretarial _____
Condition_____

16. Does workstation have a carpet?_____
Tiles?_____
Carpet tiles?_____ Condition?_____
_____

17. Does the workstation have:

a. Pictures or poster on wall ..... ____Yes ____No
b. Pictures or other mementos on desk, credenza or tack surface ..... ____Yes ____No
c. Fan ..... ____Yes ____No

18. Is there supplemental task lighting at primary/secondary task location?

Yes_____ Type_____ No_____

19. Lamp Type for task lighting

Fluor._____ CW_____ WW_____ Daylight_____ Other_____
Incandescent_____ Other_____

20. Fixture Type
Free Standing - Moveable_____
Furniture integrated_____
Desk mounted moveable_____
Other_____

21. Direction of Light
Fixed_____
Adjustable_____

22. Height of Task Light Above Task Surface
Record in inches _____IN
Varies _____

23. Instrusive Sounds

	None	Little	Some	A Lot
a. Ringing Telephones	____	____	____	____
b. Conversations of Co-workers	____	____	____	____
c. Printer or Computer Noise	____	____	____	____
d. Other Office Equipment Noise	____	____	____	____
e. Vent System Noise	____	____	____	____
f. Outside Noise	____	____	____	____
g. Music or Intercom	____	____	____	____

24. Temperature:
_____^{o}F Dry Bulb

25. Humidity
_____% Relative Humidity

26. Air Flow
_____CFM

27. Background Noise Level
_____dBA Reading Source_____

28. Headphone Noise Level

_____

29. Headphone Noise Level - Octave Band Readings

_____

_____

_____

30. Area Occupied by Person

Desk	Length_____	Width_____	Ht_____
Office Area	Length_____	Width_____	
Chair	Length_____	Width_____	
File Cabinet	Length_____	Width_____	
VDT Screen	Distance_____		

Other_____

_____

_____

NBS-114A (REV. 2-8C)

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5. AUTHOR(S)

Belinda L. Collins; Arthur I. Rubin

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

Data from a detailed evaluation of environment conditions in three U.S. Army field stations are presented. Three field stations were evaluated: Kunia, Augsburg, and Berlin. Results from a questionnaire administered to over 600 people at all sites in three job types (operator, analyst, and administrative/other) are given which indicate major concerns with conditions such as temperature, lighting, space, furniture, equipment functioning, and general environmental quality. Physical data obtained from measurements of over 270 workstations indicated the presence of cold temperatures, low light levels, reduced VDT screen contrast, glare, and distracting noises. The report provides the basic data which support the concerns expressed by Headquarters; namely, that field station personnel perform their jobs under conditions likely to impair their effectiveness. Suggestions for improving conditions are given in a companion report by Rubin and Collins.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

automation, contrast, environmental_ assessment, indoor air quality, lighting, luminance, noise, post-occupancy evaluation, temperature, VDT's

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