Dissimilar Metal Welds— Transition Joints Literature Review

Emphasis is on carbon migration, the stress/strain state of welds, and transition joint failure mechanisms

BY C. D. LUNDIN

Foreword: The review of the available literature on Dissimilar Metal Welds and Transition Joints is an outgrowth of a Metal Properties Council, Inc./EPRI sponsored effort to detail the references pertaining to the subject in an annotated bibliographic form. The reference bibliography is contained herein to provide the reader with a ready source of reference material, so that amplification of the present review is simple and direct.

The information presented has been disassociated from direct references so as to provide a more easily assimilated document. The opinions expressed are those of the author and do not necessarily reflect the views of the Metal Properties Council or the Dissimilar Weld Task Group.

Introduction

In the preparation of this review, the sources evaluated included the open literature from 1935 to the present and internal company reports and memos provided during the data accumulation stage. Failure analysis reports in published and unpublished or proprietary form also served to define the problem. Failure analysis of transition joints by the author has served to provide a basis of judge-

The industry survey conducted by Mr. Paul Haas for the Dissimilar Weld Task Group was invaluable in assessing the magnitude of the problem. This review, coupled with informal interviews with transition joint suppliers, fabricators, users and researchers, readily defined the scope of the efforts undertaken by a diverse group of interested parties.

The aim of this review is to provide an unbiased view of the reported experiTable 1—Transition Joint Behavior—Industry Survey on a per unit basis

Reported failure only after 100,000

Reported no failures

81%

	nours
63%	Reported failure with stainless
	weld metal
12%	Reported failure with Ni base weld metal
6%	Reported failure with pressure welds
17%	Reported failure with ferritic weld metal
76%	Reported failure in the superheater

ences with, and investigations and research into transition joints. The open literature provides a relatively complete picture of the general subject except for the magnitude of the problems associated with transition joints and the details of the metallurgical characteristics of the interface zones between filler metal and base metal. Informal visits revealed that the level of the problem with the serviceability of transition joints has a different magnitude depending on one's vantage point. For example, those who have to deal with stainless filler metals perceive and realize in practice far more substantial difficulties than do those who have to

Based on presentation sponsored by the Metal Properties Council at the 62nd AWS Annual Meeting in Cleveland, Ohio, during April 5-10, 1981.

C. D. LUNDIN is Professor, Department of Metallurgical and Polymer Engineering, The University of Tennessee, Knoxville, Tennestreat the nickel-base filler metal transition joints.

The internal reports have been, in general, more revealing than the open literature reportings except in the recent past. In the accomplishment of failure analyses, almost all investigations recognized the same factors although the variables are given different credence in many instances.

The industry survey conducted for the Dissimilar Weld Task Group sets the tone for future work in defining the tasks necessary for complete evaluation and understanding of transition joint behavior. The results of the survey (abridged) are briefly summarized in Table 1, and the reader is urged to review the entire

survey for a complete picture.

It is clear from examination of Table 1 that the problem, while crucial to boiler operation, is far from completely devastating as 19% of the units report failures* and, of these, 37% report use times in excess of 100,000 hours before the onset of failure. The shortest time for failure was reported to be 29,000 hours (203 start-ups) whereas the majority of the times ranged from 29,000 to 125,000 hours. The mean time to failure was calculated to be 80,000 hours. It is also clear that the superheater temperatures and conditions together with the use of stainless weld metals constituted the bulk of the failures. The Ni-base weld metals, ferritic weld metals and pressure welds constituted less than 37% of failures. (It must be recognized however that the total numbers of welds in each category must be known before sweeping conclusions can be drawn.)

^{*}Failure may include partially cracked joints and leaking joints.

Review of Literature

The chronology of use of transition joints revealed the first concerted use of austenitic filler metals by Krupp for armor steels. In the 1940's transition joints were manufactured and/or fabricated for use in boilers. These early joints were made with austenitic stainless steel filler metals. In the 1950's and 1960's there was an increase in the use of transition joints for boiler service, especially as steam temperatures rose to 1050°F (566°C). The first failures were noted in the 1950's, and efforts were undertaken to improve the behavior and to understand the failure phenomena. The 1970's and 1980's have seen increases in both the use and failure incidents of transition joints. (The exposure times have reached the 100,000+ hour mark for many of the 1960's installed transition joints.)

As the literature is read and the reportings of failure investigations noted, a number of general facts emerge which most investigators can support from their own experience. (It should be noted here that the majority of failures have been associated with austenitic stainless steel filler metal joints, and it is currently held by some investigators that the failure mode with the nickel-base filler metals is fundamentally different than that with the austenitic stainless fillers.) The general facts are as follows:

1. Failures occur almost invariably in the HAZ of the ferritic component—adjacent to the weld interface.

2. A carbon-depleted zone appears in the ferritic material adjacent to the interface and a carbon-enriched zone occurs in the stainless/Ni-base filler metal. These zones are not present in the as-welded (and diluted) condition of the weldments but appear as a result of PWHT or elevated temperature exposure.

3. The carbon-depleted (soft) zone in the low alloy material is essentially ferrite and carbide. The carbon-enriched (hard) zone may contain many constituents but

carbides predominate.

- 4. The cracking most often initiates at or near the outside surface. Differences may be apparent however for large diameter pipe and the smaller diameter tubes.
- 5. The cracking results directly from void linkup, grain boundary separation or tearing. It is generally parallel to the weld interface.
- The cracking is associated with or exacerbated by oxidation—oxide notching.
- 7. The relative expansion coefficients of the various weldment regions are extremely important with regard to thermal stress generation.

8. The type of weld metal is of major significance from the diffusion and thermal restraint standpoints.

9. Time-temperature and cyclic conditions are very germane to failure.

- 10. Bending and vibrational stresses are conceded to play a major but loosely defined role. They may provide an explanation for the apparent variability of service life.
- 11. The joint design—groove angle—and weld quality interrelationship is considered by many to be a significant variable.
- 12. Weld discontinuities play a role as stress raisers.
- 13. The carbon-depleted zone is low in strength and also weak in terms of stress rupture.
- 14. The constituents at the weld interface are difficult to identify, and the precise role of the hard constituents is questioned.
- 15. PWHT contributes to earlier failures in both stainless and Ni-base filler metal transition joints.

Carbon Migration

Carbon migration across the weld interface is considered a significant factor in the "life" of a transition joint, since time dependent property changes occur in the regions where carbon movement occurs. The carbon migration causes loss of strength in the ferritic material adjacent to the weld interface and an increase in hardness (and probably also in strength with a change in the modulus of elasticity possible) in the filler metal (carbon-enriched zone).

These zones are immediately adjacent to one another and provide a significant change in properties across a narrow region. Unfortunately, the properties of these zones are inferred from hardness traverses made at room temperature. A drop in hardness of 40 DPH in the ferritic material and a rise of 200 DPH in the filler metal is not unusual. Thus a change of 240 DPH may occur over a span of only \approx 0.010 in. (0.25 mm). A change of 240 DPH may be equivalent to approximately 120,000 psi change in strength.

Some generalizations may also be stated concerning carbon migration;

- 1. Carbon diffuses 5-10 times faster in ferrite than in austenite at the same temperature
 - (a) Carbon diffusion is temperature, time and carbon content (activity controlled).
 - (b) The carbon content in solution (activity) in ferrite and austenite is important.
 - (c) The solubility of C in austenite is higher than in ferrite.
 - (d) Carbide formers in solution in ferrite retard carbon migration or "stabilizes" the ferritic material.
 - (e) Increasing the Ni content of the filler metal alters carbon solubility, makes carbides less stable, changes diffusivity and in general retards carbon migration from the ferritic material.
 - 2. The rate controlling step is the diffu-

sion of carbon in the austenitic filler metal (be it stainless or Ni-base) or the rate of carbide formation after the solubility limit is reached.

3. Some investigators believe that thermal stresses acting on the interface enhance carbon diffusion and thus the stainless filler metal joints can experience more rapid formation of the carbon

depleted zone.

The carbon migration phenomenon has been documented to a greater extent than many other metallurgical reactions in transition joints. It is clear that some of the above factors influence both the extent (width) of the carbon depleted/ enriched zones and the magnitude of the carbon levels. Documentation of carbon migration is tedious but attainable by a variety of means. The influence of timetemperature and material composition characteristics have been determined and have resulted in the understanding of one of the influences of nickel rich weld metals – reduced carbon migration. Further, the use of stabilizing elements in the ferritic component is effective in combatting migration but not so easily employed nor ultimately effective for long time exposure. Suffice-it-to-say that carbon migration will occur at PWHT temperatures or at operating temperatures and one must mitigate against it but cannot prevent its ultimate occurrence.

Some of the most important ancillary actions of carbon migration are the mechanical property changes that obtain as a result of this migration. This is one of the least investigated metallurgical aspects of carbon movement, yet one of far reaching consequences. The microstructural changes which can be "agreed" upon by most researchers

are:
1. The dilution zone between the ferritic material and filler metal caused during weld deposition is not considered significant in terms of subsequent changes caused by thermal exposure. No carbon migration of importance occurs during normal weld deposition. The martensite layer which may form in the diluted zone is not considered detrimental to weld performance per se.

2. The development of the carbon depleted zone in the ferritic material and the carbon-enriched zone in the filler metal (stainless or Ni-base) depends on time, temperature, solubility limits, diffusion rates and stress. It is the nature of these time dependent zones that ultimately control the failure mode.

3. The carbon denuded zone exhibits low tensile and creep strength and a reduced recrystallization temperature. However, the properties are not specifically defined.

4. The stainless/Ni-base filler metal carbon-enriched zone is higher in hardness and strength than any other region, but the properties are not defined.

5. Zones of complex and varied

microstructure may exist depending on thermal treatment/welding conditions in addition to, or in concert with the "soft" and "hard" zones.

Better definition of properties is a must if further mechanism work and stress analysis evaluations are to be of any value in defining the fundamental aspects of the problem.

Stress/Strain State of Welds

Cracking cannot occur in the absence of stress (strains), regardless of the microstructure and/or its condition. For cracking to occur, the strains imposed on the various microstructural regions by weldment loadings must exceed the strain tolerance of the microstructure in one of the regions. It is often simpler and more convenient to talk of stresses. However, in the case of transition joints, it is probably more relevant to discuss the behavior in terms of strain.

The stresses and strains attendant with the production and use of transition joints arise from:

- 1. Difference in expansion coefficients of the base metals and filler metals (with the greatest difference being evident for stainless filler metals and ferritic base metals). Simple heating and cooling of joints with different coefficients produces tangential, longitudinal and radial components of stress. The radial or shear component is the most difficult to treat (especially if weld interface properties are unknown) and probably the most important with regard to behavior.
- 2. Internal pressures create stress in transition joint piping.
- External bending stress and vibrational loadings are considered very important but are difficult to assess.
- 4. Joint configuration basically groove or bevel angle controls shearing and other stresses. Graded transition joints mitigate joint configuration influences as well as differential expansion stresses per se.
- 5. Weld separation which depends on pipe or tube wall thickness and radius influences weld-to-weld interaction. The ASME spacing criteria is considered adequate to eliminate this effect.

The stress/strain state of the welds under operating conditions cries for better definition. Advances have been made with finite element techniques but a significant amount of work needs to be done. Further analyses must include:

- 1) Elastic-plastic analysis.
- Treatment of the net on a fine enough scale to account for the carbon depleted and enriched zone properties.
- 3) Time dependent creep/fatigue interaction with dwell times during load/temperature cycling.

The interaction between strain/stress state and microstructure is a most important consideration and no doubt is the controlling aspect of the problem. The

following points highlight the current assessment of this interaction:

- 1. The carbon-depleted soft zone is restrained by the harder and stronger carbon-enriched zone immediately adjacent during thermal cycling. The development of a complex stress state involving shear along the interface and an enhanced degree of triaxiality occurs, thus inhibiting uniform strain and forces deformations in the soft zone.
- 2. Plastic flow occurs by creep to relieve the imposed strains/stresses while the joint is at elevated temperature leading to a creep/fatigue type of damage in the microstructure.
- 3. The number of cycles and the times at the temperatures during cycling are important in the damage introduced into the soft zone even in the absence of any external loadings.
- The final result of the strain accomodation in the soft zone is cavitation and cracking.

This scenario is naturally a simplified picture of what appears to happen in service. Bending, vibrational and pressure variation loadings naturally contribute to the phenomenon.

Mechanism of Transition Joint Failures

The general consensus concerning the mechanism of transition joints failure can be summarized as follows: (It should again be noted that in the majority of the failures the filler metal was austenitic stainless steel, and some investigators indicate that the failure mechanism with the Ni-base filler metals may be different.)

- 1. The formation of the carbon-depleted zone is the initial step and any treatment which accelerates the formation of this zone will enhance failure probability.
- The carbon-depleted soft ferritic zone is constrained by the surrounding harder and stronger material and is subjected to strains induced by:
 - (a) Thermal expansion mismatch.
 - (b) Bending, vibration and pressure.
- 3. The strain accumulation in the carbon depleted softened zone is relieved by creep at elevated temperature.
- Creep damage in the form of cavitation, grain boundary sliding and tearing results in cracking in the carbon-depleted soft zone along and adjacent to the weld interface.

The mechanism postulated combines the reportings of many investigators and may seem over-simplified. However, complete operational information is seldom available on failed transition joints, and the metallurgical aspects are not rigorously defined. The difference in thinking concerning the Ni-base filler metals involves the reduction in rate of formation of the carbon-depleted zone

and the establishment of very complex microstructures in the carbon-enriched hard zone. It is considered by some investigators that the complex microstructural constituents and their time dependent formation are the controlling factors in the Ni-base filler metal failure occurrences. The picture is less complete in regard to Ni-base filler metal transition joints however.

As the nature of the failure phenomenon became clearer (over a period of years) methods for minimizing failures evolved. To mitigate against failure the following considerations have been cited:

- 1) Closer match of expansion coefficients in the transition joint components, i.e., Ni-base filler metals.
- 2) The use of "graded" transition joints or spool pieces which spread-out the coefficient of expansion mismatch effect.
- The use of stabilizing buttering techniques to minimize carbon migration
- 4) Stabilization of the ferritic component with carbide formers to minimize carbon migration.
- 5) Elimination of PWHT which enhances carbon migration due to the temperatures employed.
- 6) Joint configuration choice and enhanced control of weld quality.
- 7) Avoidance of bending stresses and vibrational loadings.

Techniques aimed at employing one or more of these mitigating methods have been used successfully in combatting transition joint failures. Further in-service testing is under way employing some of the methods outlined, and accelerated testing schemes will no doubt use some of these methods in the evaluation stages.

The review of the literature has revealed areas in which research and evaluation efforts need to be undertaken to better define the transition joint problem:

- 1) Better documentation of failures and more thorough failure analysis.
- Better as-welded microstructural characterization.
- 3) Microstructural studies to more clearly characterize the joint interface including the "soft" carbon-depleted zone and the "hard" carbon-enriched zone
- 4) Physical and mechanical property measurements of the zones at the interface including modulus, CTE, tensile strength and creep rupture properties.
- 5) Chemical analysis profiles for all elemental species across the interface region.
- Stress analysis work utilizing measured properties and encompassing the stress relaxation by creep during cycling.
- 7. Refinement of finite element analyses based on the above measure-

ments.

- 8. Better test procedures incorporating axial loading, bending, fatigue, and internal pressure.
 - Improved NDT techniques.
- 10. Accelerated test scheme developparametric ment - time-temperature

Many of these areas are currently being addressed by the Metal Properties Council/EPRI program, industrial in-house research and fabricator/user industry cooperative efforts. Thus, the technical community can expect a better understanding of the technical aspects of the problem areas to evolve in the near future. Furthermore, as the problem areas are defined a clearer perception concerning the possible dichotomy of failure mechanisms between the stainless steel filler metals and nickel-base filler transition joints should be evident.

Bibliography

- 1. Rapatz, F., and Humitzsch. 1935. Structure of transition fusion zone obtained in fusion welding. Archiv Eisenhuttenwesen 8(12): 555-556. Henry 8rutcher, translation no. 2202
- 2. Thielemann, R. H. 1940. Some effects of composition and heat treatment on the hightemperature rupture properties of ferrous alloys. *Proceedings A.S.T.M.* 40: 798.

3. Thomas, R. D., Jr., and Ostrom, K. W. 1941. Dilution of austenitic welds by mild steels and low alloys." The Welding Journal

20(4): 185-s to 188-s.

- 4. Herres, S. A., and Turkalo, A. M. 1946. Welding of hardenable steels with high alloy (austenitic) electrodes. Welding Journal 25(10): 669-s to 696-s.
- 5. Rohrig, I. A. 1946. A study of austenitic welding for control of graphitization in steel welding. Welding Journal 25(2):90-s to 101-s.
- 6. Seabloom, E. R. 1946. Welding methods for alloy-steel piping. Welding Engineer 31(10):
- 7. Miller, O. O., and Houston, E. G. 1947. Macro-etching and photomacrography of ferritic and austenitic welded joints in low alloy steel. Welding Journal 26(10): 620-s to 625-s.

8. Schaeffler, A. L. 1947. Selection of austenitic electrodes for welding dissimilar metals. Welding Journal 26(10): 601-s to 620-s.

- 9. Schaeffler, A. L. 1948. Welding dissimilar metals with stainless electrodes. Iron Age, 162 (July 1): 72-79
- 10. Holmberg, M. F. 1949. Welding allov steels for high-temperature service. Welding Journal 28(2): 141-148.
- 11. Lewis, K. G. 1949. Welding of high pressure air-vessel assemblies: metallurgical and mechanical considerations. Metallurgia 40:
- 12. Schaeffler, A. L. 1950. Problems associated with welding of stainless clad steel. Welding Journal 29(5): 387-390.
- 13. Weisberg, H. 1949 (Aug.) Cyclic heating test of main steam piping joints between ferritic and austenitic steels – Sewaren generating station. Transactions ASME 70: 643-649.

14. Blumberg, H., and W. Burn, Discussion to Reference 13. Ibid: 651-653.

- 15. Jackson, R. 1949 (Aug.). Discussion to Reference 13. Ibid: 655-657
 - 16. Blaser, R. U.; Eberle, F.; and Tucker, J. T.

1950. Welds between dissimilar alloys in fullsize stream piping. Proc. ASTM 50: 789-808.

17. Carpenter, O. R., Jessen, N. C., Oberg, J. L., and Wylie, R. D. 1950. Some Consideration in the joining of dissimilar metals for high temperature, high pressure service. Proc. ASTM 50: 809-860.

18. Jefferson, T. B. 1950, Joining stainless to chrome-Moly. Welding Engineer 35(3): 27.

- 19. Montandon, R. 1950. The fissuring tendency of welds made with austenitic electrodes. Brown Boveri Rev. 37: 255-264
- 20. Stewart, W. C., and Schreitz, W. G. 1950. Thermal shock and other comparison tests of austenitic and ferritic steels for main stream piping. Trans. ASME Vol. 72.

21. Wooding, W. H. 1950. Welding air hardening alloy steels. Welding Journal 29(11): 552-s to 564-s.

22. Tremlett, A. F. 1950. Trans. Inst. Welding 13: 143-156.

- 23. Zemzin, V. N. 1950. Fusion zones in welded joints between dissimilar steels. Kotloturbostroenie No. 6
- 24. Navarre, N. L. 1951. Welding procedures for high-pressure, high-temperature steam piping. Welding Journal 30(1): 1-s to
- 25. Emerson, R. W., and Hutchinson, W. R. 1952. Welded joints between metals in hightemperature service. Welding Journal 31(3): 127-s to 141-s.

26. Thielsch, H. 1952. Stainless clad steels. Welding Journal 31(3): 142-s to 159-s.

27. Thielsch, H. 1952. Stainless steel weld deposits on mild and alloy steels. Welding Journal 31 (1): 37-s to 64-s.

28. Scheil, M. A. 1953. Migration of Cr and C in a weld in Type 502. Metal Progress 64 (Sept.): 108-110.

29. Eberle, F., Ely, F. G., and Dillon, J. A. 1954. Experimental superheater for steam at 2,000 psi and 1250°F - progress report after 12,000 hours of operation. Trans. ASME 76: 665-677.

30. Lien, G. E., Eberle, F., and Wylie, R. D. 1954. Results of service test program on transition welds between austenitic and ferritic steels at the Philip Sporn and Twin Branch plants. Trans. ASME 76: 1075-83.

31. Ronay, B., and Clautice, W. E. 1954. Evaluation of superheater materials for high temperature steam. Welding Journal 33(4): 199-s to 206-s.

32. Weisberg, H., and Soldan, H. M. 1954. Cyclic heating test of main steam piping materials and welds at the Sewaren generating station. Trans. ASME 76: 1085-1091.

33. Christoffel, R. J., and Curran, R. M. 1956. Carbon migration in welded joints at elevated temperatures. Welding Journal 35(9): 457-s to 468-s.

34. Kittle, D. 8. 1956 (Nov. 20). Evaluation of weld transition joints of Type 304 stainless steel to Croloy 21/4. KAPL-M-D8K-1.

- 35. Nesbitt, L. C. 1956. Welding of hightemperature, high pressure piping with chrome-moly electrodes. Welding Journal 35(2): 129-135.
- 36. Tucker, J. T., and Eberle, F. 1956. Development of a ferritic-austenitic weld joint for steam plant application. Welding Journal 35(11): 529-s to 540-s.
- 37. Blumberg, H. S. 1957. Metallurgical considerations of main stream piping for hightemperature, high-pressure service. Trans. ASME 79: 1377.
- 38. Donahue, J. E. 1957. Butt welding austenitic stainless steel to ferritic steel in cylindrical shapes. Welding Journal 30(11): 1074-1077.

(1957).

39. Emerson, R. W., and Jackson, R. W. 1957. The plastic dutility of austenitic piping containing welded joints at 1200°F. Welding Journal 36(2): 89-s to 104-s.

40. Geerlings, H. G., and Kerkhof, W. P. 1957. Austenitic welds in Type 502 steel pip-

ing. Welding Journal 36(3): 119-s.

41. Zimmer, F. 1957. Welded joints between ferritic steels and austenitic steels. Tube Investments Limited - translation no. 1439, translation of publication issued by the Bureau d'Etudes industrielles Fernand Courtoy 5. A., 3rd and 4th ternes.

42. Lofblad and Lindh. 1959. Development of a transition weld between ferritic and austenitic superheater tubing. Welding and Metal Fabrication (Aug.-Sept.): 325.

43. Rutherford, J. B. 1959. Welding stainless steel to carbon or low-alloy steel. Welding

Journal 38(1): 19-s to 26-s.

- 44. Alco Products, Inc. 1960 (Aug. 15). Welded transition joint between 21/4 Cr-1Mo steel and Type 316 stainless steel. APAE no.
- 45. Caughey, R. H., and Benz, W. G., Jr. 1960. Material selection and fabrication, main steam piping for Eddystone no. 1, 1200°F and 5000 lb/in.² Service. Journal of Engineering Power (Oct.): 293. ASME.

46. Livshits, L. S., and Panich, S. E. 1960. Some rules for the migration of carbon in welded joints in pearlite steels. Welding Pro-

duction (5): 42-45.

47. Witherell, C. E., 1960. Welding of nickel-chromium-iron alloy for nuclear-power stations. Welding Journal 39(11): 473-s to 478-s.

- 48. Clautice, W. E. 1961. Evaluation of weldments joining superheater tube alloys after exposure to steam temperatures of 1100-1500°F. ASME Publication, Paper #61-PWR-5.
- 49. Gotal'Skii, Yu, N. 1961. Features of the welding of dissimilar steels. Automat. Weld. (8): 45-53.
- 50. Zemzin, V. N. 1961. The long time strengths of welded joints between austenitic steels and pearlitic or chromium steels. Weld. Prod. 8(7): 1-10.
- 51. Emerson, R. W., and Dauber, C. A. 1962. Transition joints between austenitic and ferritic steel piping. Welding Journal 41(9): 385-s to 393-s.
- 52. Livshits, L. S. 1962. Structural heterogeneity in fusion regions and calculation of the composition of the metal in welded joints. Welding Production 9: 1-8.

53. Livshits, L. S., and Bakhrakh, L. P. 1962. The welding of steels of dissimilar structural categories. Welding Production 11: 12-17.

- 1962. Welded joints 54. Zimmer, F. between steels of different compositions used in the construction of superheaters and reheaters. Annexe duBull d L'Aim (7)
- 55. Brister, P. M., and 8ressler, M. N. 1963. Long time experience with steel and alloy superheater tubes in power boiler service. Joint Intern'l Conference on Creep, London
- 56. Harlow, J. H. 1963. Metallurgical experience with the Eddystone 5000 lb/in.2 1200°F unit no. 1. Proc. Joint Intern'l Conference on Creep, New York.
- 57. Wyatt, L. M., and Gemmil, M. G. 1963. Experience with power generating steam plant and its bearing on future developments. Paper 4, Joint International Conference on Creep, New York and London.

58. Eckel, J. F. 1964. Diffusion across dissimilar metal joints. Welding Journal 43(4): 170-s to 178-s. (1964).

59. Gotal'Skii, Y. N. 1964. The problem of welding dissimilar steels in structures intended for use for long periods at high temperatures. Automatic Welding 17 (12): 34-40.

60. Slaughter, G. M. 1964. The welding of ferritic steels to austenitic stainless steels. Welding Journal 43(10), 454-s to 460-s.

61. Thorneycroft, D. R. 1964 The Dissimilar Metal Joint. Publ. no. 2876, London: Interna-

- tional Nickel Company, Ltd. 62. Hawley, A. 1965. Semi-automatic transition welding method for present and future thermal power station tube requirements. Welding and Metal Fabrication 33(9): 382-384.
- 63. Hopkins, et al. 1965. Creep properties of some butt welds in steam pipes. Journal of the Iron and Steel Institute 203: 815-826.
- 64. Jones, I. J. 1965. Practical applications of friction welding. Welding and Metal Fabrication 33(9): 377-382.
- 65. Slater, D., and Winn, J. M. 1965. The fusion boundary between mild steel and high alloy steel weld metal. Proc. of the Second Commonwealth Welding Conference, Paper M 12. London. Institute of Welding.

66. Thielsch, H. 1965. Defects and failures in pressure vessels and piping, p. 77. New York: Reinhold Publishing Company

- 67. Gotal'Skii, Yu. N.; Snisar', V. V.; and Tyskulenko, A. A. 1966. An electrode wire for the submerged arc welding of dissimilar steels. Automatic Welding 10: 75.
- 68. Ignatov, V. A.; Zemzin, V. N.; and Petrov, G. L. 1967. Effects of nickel in austenitic welds on the migration of carbon in welded joints between dissimilar steels. Automatic Welding 8: 1-6.
- 69. Ito, Y., and Ishii, K. 1967 (Oct.). A study (of the mechanical and weld properties) of a transition piece for super-heater tube of power plant. Sumitomo Metal 19(4): 46-57

70. Linnert, G. E. 1967. Welding Metallurgy. Vol. 2, pp. 270-272. New York: American Welding Society.

71. Medovar, 8. I., et al. 1967. New methods of producing intermediate pieces for welding dissimilar steels. Automatic Welding

72. Gotal'Skii, Yu. N., and Snisar, V. V. 1968. An electrode wire for welding dissimilar steels intended for use at temperatures up to 550°C. Automatic Welding 3: 76-77

73. Gotal'Skii, Yu N., and Struina, T. 1968. Distribution of carbon in the fusion zone between dissimilar steels immediately after welding. Automatic Welding 10: 16.

- 74. Gotal'Skii, Yu. N., and Snisar', V. V. 1968. The nickel content of the weld metal in welded joints between austenitic and nonaustenitic steels. Automatic Welding 12: 8-
- 75. Tankaka, J., and Hano, T. 1968. Study on the dissimilar welding between Cr-Mo steel and austenitic stainless steel. Nippon Kokan Technical Report No. 44: 428.
- 76. Adams, D. F. 1969. Dissimilar metal joints for high temperature application. Met. Constr. and Brit. Welding Journal 1(12s): 41-
- 77. Barford, J., Discussion on transition joints for high temperature service. Met. Constr. and Brit. Welding Journal 1(12s): 136.
- 78. Bartle, P. M. 1969. Diffusion bonding and friction welding, two newer processes for the dissimilar metal joints. Met. Constr. and Brit. Welding Journal 1(12s): 88-95.

79. Bennett, A. P., and Eaton, N. F. 1969. Electro-slag melted transition-piece units as an alternative to direct welding. Met. Constr. and Brit. Welding Journal 1(12s): 59-65.

80. Cook, T. R., and Marshall, P. 1969. Prediction of failure of materials under cyclic loading. International conference on thermal stresses and thermal fatigue, Berkeley Nuclear Laboratories, CEGB, England.

81. Eaton, N. F., and Glossop, B. A. 1969. The welding of dissimilar creep-resisting ferritic steels. Met. Constr. and Brit. Welding Journal

1(12 Supplement): pp. 6-10.

82. Frost, F. P. 1969. Service experience with some dissimilar metal welds in the process industry, Met. Constr. and Brit. Welding Journal 1(12s): 32-35.

83. Glossop, R.; Hall, D.; and Irvin, J. 1969. Paper no. 17 - the welding of high pressure pipework for the CEG8. Conference on pipe welding, the Welding Institute, Cambridge.

84. Gotal'Skii, Yu. N. 1969. Certain special features of the failure of welded joints between dissimilar steels when subjected to loads for long periods at high temperature. Automatic Welding 7: 5-8.

85. Gotal'Skii, Yu. N., and Vasil' Ev, V. G. 1969. Effects of the nickel content of Cr-Ni weld metal on its coefficient of linear expan-

sion. Automatic Welding 5: 8-13.

86. Hadril, D. M., and Russel, J. D. 1969. Cracking associated with dissimilar metal welds at the top ends of reformer tubes. Metal Construction 12

87. Mather, J. 1969. Local bending stresses in joined pipes of dissimilar metals. Met. Constr. and Brit. Welding Journal 1(1): 48-51.

88. Payne, B. E. 1969. Ni-base welding consummables for dissimilar metal welding applications. Met. Constr. and Brit. Welding Journal 1(12s): 79-87

89. Roshchin, V. V., et al. 1969. Residual stresses in pipe joints between dissimilar steels.

Welding Production 9: 55-58.

90. Rowley, T.; Rowberry, T.; and Alldridge, C. 1969. Problems associated with the design inspection and use of large diameter ferritic/austenitic joints in power plant. Met. Constr. and Brit. Welding Journal 1(12s): 13.

91. Wood, D. 1969. Discussion session 4, welding dissimilar metals. Met. Constr. and

Brit. Welding Journal: 134-36.

92. Mullery, F. 1969. Discussion session 4, fabrication and service experience of welding dissimilar metals conference. Met. Constr. and Brit. Welding Journal 1(12 Supplement): 143-

93. Wright, V. 1969. Service experience with austenitic/ferritic superheater transition welds within CEGB (Midlands). Met. Constr. and Brit. Welding Journal 1(12s): 1.

94. Wyatt, L. M. 1969 (Dec.). Dissimilar metals joints used in the steam circuit of electrical generating plant. Metal Construc-

95. Wyatt, L. M. 1969. Discussion session 3, transition joints for high temperature service. Metal Construction 12.

96. Gotal'5kii, Yu. N., and 5truina, T. A. 1970. Distribution of carbon in the fusion zone between dissimilar sheets when there is structural heterogeneity in the zone. Automatic Welding 4: 19-23.

97. Gotal'Skii, Yu. N., and Snisar, V. V. 1970. Wire for welding dissimilar steels. Welding Production 2: 68-70.

98. Kent, R. P. 1970. Investigations into Rex 500/Inconel weld failures. Conference on Welding Creep Resistant Steels, Welding Institute, pp. 1-17, Discussion, pp. 185-193.

99. Rowberry, T. R.; Bagnall, B. L.; and Williams, J. A. 1970. An analysis of service experience with large austenitic-ferritic steampipe joints in CEGB Midland Region plant. CEGB Report.

100. Rowberry, T. R., Bates, P. B. 1970. Service simulation tests on austenitic/ferritic transition joints for steam pipe application, part II: metallurgical examination of four joints. SSD/MID/R231/70, Mid. Reg. 5.5.D.

101. Toft, L. H.; Rowberry, T. R.; Rowley, T.; Mellor, H. G.; and 8arford, J. 1970. The correlation of service simulation tests of welds in a creep-resisting steel steampipe with service performance. Proc. conf. on welding creep resistant steels, Welding Institute: 18-

102. Yamamoto, S.; Ohta, S.; and Kamei, B. 1970. Journal of the Materials Science Society

of Japan 19: 196.

103. Gotal'5kii, Yu. N. 1971. Special features of the solidification of weld metal in the fusion zone between dissimilar steels. Automatic Welding 6: 10-14.

104. Heap, H. R., and Riley, C. C. 1971. Development of brazed austenitic/ferritic steel steam pipe joints for turbines. Welding Journal 50:(6)253-s to 260-s.

105. Kenyon, N. 1971. Some observations on the stress rupture ductility of welds. Weld-

ing Journal 50(6): 261-s.

106. Lewis, D. J.; Chubb, E. J., and Money, H. A. 1971. Factors affecting thermal stress in power plant. Thermal stresses & thermal fatigue, Central Electricity Generating 80ard, ed. D. J. Littler, pp. 324-339. London, England: Butterworth & Co., Ltd.

107. Barford, J., and Probert, K. 1972 (Sept.). Interfacial effects in dissimilar steel joints. Presented at international conference on welding related to power plants, The

Welding Institute.

108. Gemmil, M. G. 1972. The technology and properties of ferrous alloys for high temperature use. CRC Press. 186-201. (1972).

109. Gotal'Skii, Yu. N.; Makhnenko, V. I.; and Shekera, V. M. 1972. Effects of nickel in austenitic weld metal on the stresses in joints between dissimilar steels. Automatic Welding 5: 24-28 (1972)

110. Hardy, A. K.; Goodall, I. W.; and Rowley, T. 1972 (Sept.). Design and operational aspects of steam pipe transition joints. Presented at the international conference on welding research related to power plant. (Sept.) 1972.

111. Huntington Alloy Products Division. 1972. Joining Huntington Alloys. 62, 66-67.

Technical bulletin.

112. Lucas, W., and Nicholas, E. D. 1972. Potential of friction welding techniques. International conference on welding research related to power plant, The Welding Institute, Abington, Cambridge, England, CEGB. (1972).

113. Toft, L. H., and Yeldham, D. E. 1972. Weld performance in high pressure steam generating plant, Midlands Region, CEGB. International conference on welding research related to power plant, CEGB, Midlands Region, Scientific Services Department, Ratcliffe-on-Soar, Notthingham, England. (1972).

114. Walters, D. J.; Rowley, R.; and Elder, W. J. 1972. The creep assessment of butt welded pipes and tubes, Welding Research Related to Power Plants, eds. by Wyatt, L. M., and Eaton, N. F., pp. 92-100. London: CEGB. (1972).

115. Yapp, D., and Bennett, A. P. 1972. Development of electroslag-melted graded transition joints. Proc. international conference on welding research related to power plant.

116. Coleman, M. C., and Williams, J. A.

1973. Creep damage accumulation during thermal cycling of a transition joint. CEGB Report R/M/R207. (1973).

117. Dalder, E. N. C. 1974. Ferritic steel: austenitic steel transition welds, a review of available information.U. S. Atomic Energy Commission. (1974).

118. Jones, W. K. C. 1974. Heat treatment effect of 2 Cr-Mo joints welded with a nickel-base electrode. *Welding Journal* 53(5): 225-s to 231-s.

- 119. Westinghouse Electric Corporation failure and incident report no. 032-interim no. 1, 1974.
- 120. King, J. F. 1975 (Nov.). Behavior and properties of welded transition joints between austentitic stainless steels and ferritic steels a literature review. ORNL-TM-5163.
- 121. Anon. 1975 (Feb.). Results of examination by Japanese of Fermi secondary loop transition joints. (304L/2½ Cr-1Mo) DOC. SJ256 75-01.

122. Westinghouse Electric Corporation. Unusual occurrence report 74-032-final.

123. Dalcher, A. W., and Yang, T. M. 1976 (Aug.) High temperature elastic analysis of dissimilar metal welded pipe joints. *Proceedings of the second international conference on mechanical behavior of materials, 1978-1983.*

124. Makara, A. M., et al. 1976. The chemical heterogeneity of the fusion zone of joints in medium alloy steels with an austenitic weld metal. *Automatic Welding* 4: 1-3.

125. Noland, R. A.; Stone, C. C.; Szymko, C. T.; and Bump, T. R. 1976. *Dissimilar metal weld technology*. ANL report, pp. 226-227.

126. Sullivan, M. D. 1976 (Jan.). An investigation of alternate methods of transition joint fabrication. NEDM-14089.

127. Yang, T. M. 1976 (May). A summary of the effects of material combinations and weld joint geometries on the elastic stress in a dissimilar metal pipe joint. NEDM-14109.

128. Anan'Eva, N. S., et al. 1977. The residual stresses in cylindrical welded shells made of dissimilar steels. *Automatic Welding* 6: 32-34

129. Brinkman C. R.; King, J. F.; Strizak, J. P.; Kleuh, R. L.; and Booker, M. K. 1977 (May). Mechanical properties of transition joint materials in support of LMFBR steam generator design. International conference on ferritic steel for fast reactor steam generators, British Nuclear Energy Society, London, paper 82.

130. Dalcher, A. W.; Yang, T. M.; and Chu, C. L. 1977. High temperature thermal-elastic analysis of dissimilar metal transition joints. *Trans. ASME:* 65-69.

131. Gotal'Skii, Yu. N. 1977. A new factor causing structural heterogeneity to develop in fusion zones between dissimilar steels. *Automatic Welding* 5: 8-11.

132. Gray, R. J.; King, J. F.; Leitnaker; and Slaughter, G. M. 1977 Examination of a failed

transition weld joint and the associated base metals. *Microstructural science*, vol. 5, eds. Braun, Arrowsmith, and McCall.

133. Hardy, A. K.; Rowley, T.; and William, T. A. 1977 (May). Austenitic/ferritic welded transition joints for high temperature applications. International conference on ferritic steel for fast reactor steam generators, British Nuclear Energy Society, London, paper 80.

134. Jackson, P. W.; Chadwick; and Graham, B. L. 1977. Explosive welding of ferritic/ferritic and ferritic/austenitic steel joints. International conference on ferritic steel for fast reactor steam generators, British Nuclear Energy Society, London, paper 81.

135. James, L. A., Fatigue-Crack Growth Behavior in Dissimilar Metal Weldments. HEDL-TME 76-93. LIC 79 b.b.

TME, 76-93, UC-79 b.h.

136. King, Gray, Leitnaker & Slaughter, 1977 (Jan.). Examination of a failed transition weld joint & the associated base metals. ORNL-5223.

137. King, J. F., et al. 1977. Development of an improved stainless steel to ferritic steel transition joint. *Welding Journal* 56(11): 34-45

138. King, J. F., and Slaughter, G. M. 1977 (May). Transition joint welding development for LMFBR steam generators. International conference on ferritic steel for fast reactor steam generators, British Nuclear Energy Society, London, paper 79.

139. Klueh, R. L., and Kings, J. F. Creep and creep-rupture behavior of ERNiCr-3 weld

metal. ORNL report.

140. Rowberry, T. R., and Bagnall, B. I. Austenitic/ferritic steampipe transition joints in Midlands Region plant: Service experience to December 1977. CEGB SSD/MID/R66/78.

141. Sinal, J., and Zapletalek, A. 1977 (Apr.). The effects of alternating heating and cooling down on service life of joints between dissimilar metals. International Institute of Welding, Bratislava.

142. Slaughter, G. M., et al. 1977 Welding the liquid metal fast breeder. *Welding Design and Fabrication* 50(1): 65-69.

143. Thielsch, Helmut. 1977. Expansion of ruptured tube weld involving dissimilar materials of Type 304 stainless steel to 21/4 Cr-1Mo alloy steel tubing in reheater pendant assembly, unit no. 2. Bowen Steam Plant, Georgia Power Company, report no. 1626.

144. Brinkman, C. R., King, J. F., Strizak, J. P., Kleuh, R. L., and Booker, M. K. 1978. Mechanical properties of transition joint materials in support of LMFBR steam generation design. *Proc. Conference on Ferritic Steels for Fast Reactor Steam Generators*. BNES.

145. Day, R. A. 1978 (Dec.) Baseline inspection of three transition joint life test articles. GEFR-00414.

146. Haas, P. E. 1978. Results of industrywide survey on dissimilar metal weld performance. Am. Electric Power Service Corporation.

147. Hartle, R. T., et al. 1978 (Dec.). *Transition joint welding—life test article fabrication*. GFBR-00422.

148. Igumnov, V. P., et al. 1978. The fatigure strength of welded joints in dissimilar steels subjected to high-temperature loading. *Welding Production* 25: 45-48.

149. Jolliffe, V. C. 1978 (March). Finite element analysis of the stress intensity factors of cracks in welded transition joints. CEGB DOC

R/M/R263.

150. Jolliffe, V. C., and Williams, J. A. 1978 (Oct.). Thermal cycling behavior of a cracked transition joint between austenitic and ferritic steels welded with a austenitic weld metal. CEGB Research Division, Marchwood Engineering Laboratories Report R/M/R271.

151. King, J. F.; Slaughter, G. M.; and Sullivan, M. D. 1978. Transition joint welding development for LMFBR steam generators. *Proc. Conference on Ferritic Steels for Fast Reactor Steam Generators.* BNES, (1978).

- 152. Long, S. S., and Ellis, F. V. 1978 (Dec.). Thermal stress analysis of dissimilar metal welds. *Properties of Steel Weldments for Elevation Temperature Containment Applications*, pp. 77-90. New York: ASME. (Dec.) 1978.
- 153. Mitchell, M. D., Offer, H. P., and Ring, P. J. Carbon migration in transition joint welds. G. E. Report GEFR-00328 UC-79H,K.
- 154. Westwood, H. J., Moles, M. D. C., and Tinkler, M. J. 1978 (Sept.). Experimental comparison of 3 types of superheater tube transition weld under simulated 'two-shift' conditions. Ontario Hydro Research Division Report No. 78-410-K. 1978. (Sept.).

155. Blevins, R. D. 1979. (July). *Elastic stresses in bimetallic pipe welds*. GA-A15472, General Atomic Company. (July, 1979).

- 156. Faber, G., and Gooch, T., Welded joints between stainless and low alloy steels: current position. IIW Report IX-49-79, pp. 1-13.
- 157. Goodwin, G. M., and King, J. F. 1979 (May). Bridging the gap between dissimilar materials. *Welding Design and Fabrication*: 90-91.
- 158. Mitchell, H. P., and Offer. 1979 (Apr.). The effects of thermal aging on the mechanical properties of a 2½ Cr-1Mo steel/Inconel 82 transition joint fusion zone. GEFR-00446. (April 1979).
- 159. Soo, J. N., Nath, B., King, B. L., and Townsend, R. D. 1979 (Jan.). Experimental validation programme on the properties of Hartlepool/Heysham and Dungeness B boiler transition joints. CERL report LM/MATS/241. (Jan.) 1979.

160. French, David N. 1981 (May). Highnickel joints unite dissimilar steels. *Welding Design and Fabrication* 54: 92-93. (May) 1981

American Welding Society, Inc.

Report on Financial Statements And Supplemental Material Year Ended May 31, 1981

Seidman & Seidman

444 Brickell Avenue, Suite 900, Miami, Florida 33131 . (305) 371-6363

CERTIFIED PUBLIC ACCOUNTANTS

Board of Directors American Welding Society, Inc.

We have examined the balance sheet of American Welding Society, Inc., as of May 31, 1981 and the related statements of revenue and expense, changes in fund balances and changes in financial position for the year then ended. Our examination was made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the financial statements mentioned present fairly the financial position of American Welding Society, Inc. at May 31, 1981 and the results of its operations, changes in its fund balances and changes in financial position for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the prior year.

Certified Public Accountants

Miami, Florida October 30, 1981

AMERICAN WELDING SOCIETY, INC. BALANCE SHEET — May 31, 1981

\$ 73 660 324 875 275 335 278 474 162 959	1 115 303 2 610 482	38 340 12 149	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	\$ 36 122 430 877	533 107 331 159	1 331 265	1 504 648 45 708 19 057	2 900 678	211 161 664 435	\$3 776 274
Interfund Eliminations \$(180 904)	(180 904)	(150 362)			\$(331 266)	(331 266)		(331 266)		\$(331 266)
Safety and Health Fund \$ 150 33 000	136 493	\$136 493							\$136 493	\$136 493
Awards Fund \$73 410 1 358	74 768	\$74.768			\$ 100	100		100	74 668	\$74 768
Reserve Fund \$ 100 291 875 77 561	369 536	38 340 150 362 \$558 238							558 238	\$558 238
Operating Fund 5.73 977 278 474 162 959	715 410 2 610 482	12 149		\$ 36 122 430 877	533 107 331 159 331 166	1 662 431	1 504 648 45 708 19 057	3 231 844	106 197	\$3 338 041
CURRENT: Cash, including certificate of deposit of \$66,000 Short-term investments Accounts receivable, less allowance of \$100,000 Inventories Due from operating fund Other (Note 1)	TOTAL CURRENT ASSETS and 4) less accumulated depreciation	Investment in bonds Refundable deposits Due from operating fund	LIABILITIES AND FUND BALANCE	Checks issued against future deposits Accounts payable and accrued expenses Current maturities of long-tarm debt	(Notes 3 & 4) Deferred revenue Due to other funds	TOTAL CURRENT LIABILITIES	Long-term debt, less current maturities (Note 4) Obligation under capital lease (Note 3) Customer deposits	TOTAL LIABILITIES	DEFERRED REVENUE (Note 5) FUND BALANCE	

See accompanying summary of accounting policies and notes to financial statements.

AMERICAN WELDING SOCIETY, INC. STATEMENT OF REVENUE AND EXPENSE

for the year ended May 31, 1981

Excess (Deficiency)

of Revenues Over Expenses	\$ 591 584	169 978	55 734 18 200	10 198	(107 153) (157 875)	(1 248 454)	(365 094)	50 551		
Direct Expenses	\$ 518 197 648 274	766 703	190 745 467 442	27 795 94 966	757 196 295 803	1 248 454	\$5 015 575		\$ 69 270	\$ 69 270
Revenues	\$1 109 781 1 045 734	936 681	246 4/9 485 642	37 993 200	650 043 137 928		\$4 650 481	\$ 50 551	\$ 61 217 8 053	\$ 69 270
OPERATING FUND ACTIVITIES:	hip on		alification and certification scation	IIW Communication	Welding Journal Building operations			RESERVE FUND INTEREST INCOME	SAFETY AND HEALTH FUND DONATIONS (Note 5) INTEREST (Note 5) RESEARCH PROGRAM EXPENSES (Note 5)	

(DEFICIENCY) OF REVENUES OVER EXPENSES

See accompanying summary of accounting policies and notes to financial statements.

\$(314 543)

AMERICAN WELDING SOCIETY, INC. STATEMENT OF CHANGES IN FUND BALANCES for the year ended May 31, 1981

Total	\$1 207 435 (223 404)	984 031	(314 543)	(5 053)	\$ 664 435
Safety and Health Fund	\$155 352 (155 352)				
Awards Fund	\$68 052 (68 052)				
Reserve Fund	\$512 740	512 740	50 551	(5 053)	\$558 238
Operating Fund	\$471 291	471 291	(365 094)		\$106 197
	BALANCES, at beginning of year, as previously reported Adjustments to opening balances (Note 5)	Balance, as restated	ADD—(Deliciency) excess of revenue over expenses DEDUCT—Adjustments	to renect non-current investments at mar- ket	BALANCES, at end of year

AMERICAN WELDING SOCIETY, INC. STATEMENT OF CHANGES IN FINANCIAL POSITION for the year ended May 31, 1981

Total	\$ 314 543	(138 814)	194 588 2 147 071 587 435	5 053	2 934 147	2 137 791 29 928	19 784 6 616	2 194 119	\$(740 028)
Interfund Eliminations				(150 362)	(150 362)				\$ 150 362
Safety and Health Fund		\$ 18 859	18 859		18 859				\$(18 859)
Awards Fund							6 616	6 616	\$6 616
Reserve Fund	\$(50551)		(50551)	14 977 5 053	(30 521)	29 928		29 928	\$ 60 449
Operating Fund	Deficiency (excess) of revenues over expenses \$ 365 094 Add (deduct) items not (requiring) providing working capital:	Depreciation (138 814) Change in deferred revenue	Total absorbed by (provided from) operations 226 280 Additions to property and equipment 2 147 071 Reduction of long-term debt 587 435	(non-current portion) Unrealized loss on long-term investments	Total 3 096 171	SOURCE OF WORKING CAPITAL: Additions to long-term debt Decrease in long-term investments	Increase in customer deposits and other liabilities 19 784 Increase in deferred revenues	Total 2 157 575	(DECREASE) INCREASE IN WORKING CAPITAL \$(938 596)

See accompanying summary of accounting policies and notes to financial statements.

AMERICAN WELDING SOCIETY, INC. STATEMENT OF CHANGES IN FINANCIAL POSITION (continued) for the year ended May 31, 1981

Total	\$ 5608 24875 (65333) (44752)	110 145	30 543	5 400 (533 107) (221 387)	(1/4 17)	(770 571)	\$(740 028)
Interfund Eliminations		\$(16 465)	(16465)		166 827	166 827	\$ 150 362
Safety and Health Fund	\$ 150 (47 000)	27 991	(18 859)				\$(18 859)
Awards Fund	\$ 5 358 1 358		6 716		(100)	(100)	\$ 6 616
Reserve	\$ 100 71 875	(11 526)	60 449				\$ 60 449
Operating Fund	\$(66 691) (44 752)	110 145	(1 298)	5 400 (533 107) (221 387)	(166 727)	(937 298)	\$(938 296)
CHANGES IN WORKING CAPITAL ITEMS:	Increase (decrease) in current assets: Cash Short-term investments Accounts receivable Inventories	Other Due from other funds	Total	Checks issued against future deposits Current maturities of long-term debt Accounts payable and accrued expenses	Due to other funds	Total	(DECREASE) INCREASE IN WORKING CAPITAL

See accompanying summary of accounting policies and notes to financial statements.

AMERICAN WELDING SOCIETY, INC. SUMMARY OF ACCOUNTING POLICIES

Description of Business

The American Welding Society, Inc. is a not-for-profit, technical society, exempt from income tax under Section 501 (c)(3) of the Internal Revenue Code. However, certain publications advertising revenue and rental income, considered unrelated business income, are taxable to the Society for income tax purposes.

FUND ACCOUNTING

The Society has four funds, which are described as follows:

Operating Fund—This fund is used to account for all resources over which the Society has discretionary control, except for those unrestricted resources accounted for in the Reserve Fund.

Reserve Fund—This fund is used to account for Board designated reserve funds which are to be used to supplement the cash needs of the operating fund.

Awards Fund—This restricted fund is used to account for cash donated to the Society to finance awards for contributions to welding technology.

Safety and Health Fund—This restricted fund is used to account for cash donated to the Society to fund research programs for the study of various environments to which welders may be exposed.

INVENTORIES

Inventories are values at the lower of cost or market. Cost is determined by the first-in, first-out (FIFO) method.

PROPERTY, EQUIPMENT AND DEPRECIATION

Property and equipment are stated at cost. Expenditures for additions, renewals and betterments are capitalized; expenditures for maintenance and repairs are charged to expenses as incurred. Upon retirement or disposal of assets, the cost and accumulated depreciation are eliminated from the accounts and the resulting gain or loss is included in income. Depreciation is computed using the straight line method over the following estimated useful lives:

	Years
Buildings and improvements	14-20
Office furniture and equipment	5-7
Transportation equipment	3

REVENUE RECOGNITION

Welding show revenues and expenses are recognized in the year that the show to which they relate is held.

Membership and subscription revenues in the Operating Fund are deferred when received and recognized as revenue when earned, substantially in the subsequent year.

Donations, restricted as to use, and related investment income are deferred when received, and recognized as revenue when specific restrictions are met.

AMERICAN WELDING SOCIETY, INC. NOTES TO FINANCIAL STATEMENTS

NOTE 1—OTHER CURRENT ASSETS

Included in other current assets is \$100,000 due on a fidelity bond resulting from a defalcation of accounts receivable. The amount of the loss has not been finally determined but may exceed \$135,000. Under certain circumstances additional amounts may be recoverable which will be recorded at the time such recoverability becomes known.

NOTE 2-PROPERTY AND EQUIPMENT

Major classes of property and equipment consist of the following:

Land Buildings and improvements Office furniture and equipment Transportation equipment	\$ 878 740 1 591 523 487 975 9 154 2 967 392
Less accumulated depreciation and amortization	356 910
Net property and equipment	\$2 610 482

Land, buildings and building improvements with a net carrying amount of \$2,329,096 are pledged as collateral on certain long-term debt.

NOTE 3—CAPITALIZED LEASE

The Society leases its data processing equipment under terms requiring the classification as a capital lease. The amount capitalized and related amortization at May 31, 1981 are \$75,971 and \$5,426 respectively.

The following is a schedule by years of future minimum lease payments:

1982 1983 1984	\$ 33 582 33 582 16 790
Total minimum lease payments Less amount representing interest, calculated at the Society's incremental borrowing rate	83 954 17 002
Present value of minimum lease payments Less current maturities	66 952 21 244
	\$ 45 708

NOTE 4-LONG-TERM DEBT

Long-term debt at May 31, 1981 consists of the following:

Note payable, bank, payable in monthly installments of \$50,000 plus interest at 1% over prime (a)	\$ 628 000
8½%, first mortgage, payable in monthly installments of \$7,690, including principal and interest, with a final balloon payment of \$78,315 due in August, 1988	918 262
8½%, second mortgage, payable in monthly installments of \$3,116, including principal and interest	199 054
11%, purchase money mortgage, payable in monthly installments of \$4,540, including principal and interest	271 195
Totals	\$2 016 511
Less current maturities Total long-term debt	511 863 \$1 504 648

⁽a) Subsequent to year end, the bank agreed to extend a short-term borrowing of \$628,000 to a note payable in monthly installments of \$50,000 commencing September 15, 1981 with a final payment of \$28,000 due on September 15, 1982. The Society has pledged as collateral to the bank a mortgage receivable in the amount of \$1,000,000. (See Note 6)

NOTE 5—DEFERRED REVENUE

In accordance with the provisions of the *Statement of Position 78-10, Accounting Principles* and Reporting Practices for Certain Nonprofit Organizations issued by the American Institute of Certified Public Accountants, the Society has restated its opening Awards and Safety and Health Fund balances so as to exclude from balances, revenues that have not as yet been expended for the purposes intended. These amounts are now accounted for as deferred revenues. The following schedule summarizes the activity in the individual deferred revenue accounts from June 1, 1980 to May 31, 1981:

	Awards Fund	Safety and Health Fund
Deferred revenue June 1, 1980 Contributions received for the year	\$68 052	\$155 352
ended May 31, 1981 Interest earned on restricted funds Disbursements in accordance with donor restrictions, amortized to in-	6 616	42 358 8 053
come		(69 270)
Deferred revenue, May 31, 1981	<u>\$74 668</u>	\$136 493

NOTE 6—SUBSEQUENT EVENTS

Subsequent to May 31, 1981, the Society sold certain land and buildings for approximately \$1,100,000. The Society received approximately \$13,000 in cash (net of \$87,000 expenses of sale) and a purchase money mortgage in the amount of \$1,000,000.

The purchase money mortgage bears interest at a rate of 12% per annum and is payable in twelve monthly installments of \$50,000 plus interest commencing September 1981. Thereafter, commencing in August 1982, eight annual interest only payments are payable with the balance of \$400,000 together with any unpaid interest due in August 1991. This mortgage receivable has been pledged as collateral for the note payable, bank. (See Note 4)