CRITERION 7. FACILITIES

A. Space

The Department is located on the first floor of the Mineral Industries (MI) building. The facilities that include office space and instructional laboratories occupy approximately 12,000 square feet on the first floor of the MI building and are supplemented with facilities associated with the MET Foundry, the Engineering and Mining Experiment Station (EMES) located in the MI building, and the Advanced Materials Processing Center (AMP) located in the Civil/Mechanical Building.

1. Offices (Administrative, Faculty, Clerical, Teaching Assistants)

Adequate office space is available to support the program. Table 7-1 summarizes the location and size of offices available to departmental personnel.

Table 7-1
OFFICE FACILITIES

Program: Metallurgical Engineering

Room Number	Occupant(s)	Area (sq. ft.)
Administrative		
MI 112	Dr. Jon Kellar (Head)	166
Faculty		
MI 114	Dr. Stanley Howard	160
MI 104	Dr. Dana Medlin	128
MI 110	Dr. William Cross	128
MI 101	Dr. Michael West	139
Clerical		
MI 115	Ms. Cindy Hise	245
Research Scientists		
MI 106	Dr. Haiping Hong	130
CM 236A	Dr. Bharat Jasthi	130
Teaching Assistants		
MI 128A	Teaching Assistants	330
Undergraduate Commons		
MI 105	Undergraduates	290
		Total Area = 1846

2. Classrooms

The campus currently includes 651,847 square feet of building space with 33,374 square feet devoted to classrooms, 139,416 square feet devoted to instructional and research laboratories and 75,162 square feet devoted to offices and administration. Two building are now under construction, The Paleontology Research Laboratory (33,000 square feet), and the Chemical and Biological Engineering/Chemistry Building Addition (45,000 square feet). In addition, the Tech Development Laboratory is located near campus, and the Black Hills Business Development Center is located on campus but is run as a collaborative enterprise between the School of Mines and the regional

economic development entities. Specific classroom space is not held by the Metallurgical Engineering program or the Materials and Metallurgical Engineering Department. All classrooms are scheduled by the institutional scheduling office or (for special technology classrooms) by Instructional Technology Services. Almost all classrooms are equipped with ceiling mount projectors and computers, with some classrooms also equipped with ELMOs. General purpose computer laboratories are maintained by Information and Technology Services (ITS) in all academic buildings, the library, the student center and each residence hall. Laboratory computers are on a three-year replacement cycle.

Two circumstances have created temporary strain on classroom resources. Pending the opening in fall 2010 of the University Center, West River, in Rapid City, students enrolled in nearby Black Hills State University but attending classes in Rapid meet on the School of Mines campus. This special arrangement ends in fall 2010. Also having an impact on classroom availability is the construction of the Chemical and Biological Engineering/Chemistry Building Addition. The addition will add 45,000 square feet of laboratory, office, and classroom space and will be open for fall 2010 semester. Beginning in fall 2010, considerably more classroom and lab resources will become available. Computers and electronic multi-media (projectors, a/v systems, etc.) are supported by the SDSM&T Information and Technology Services (ITS).

3. Laboratories

Table 7-2 and the individual laboratory course descriptions (given below) summarize the major laboratories used by the program. Recent laboratory upgrades and related support programs such as at the Engineering and Mining Experiment Station (EMES), Advanced Materials Processing Center (AMP), and the Center for Advanced Manufacturing and Production (CAMP) have greatly enhanced the laboratory facilities since the last ABET visit. In general, the capability and condition of laboratory facilities can be considered to be "good."

What follows below is a description of the departmental laboratory courses and an assessment of the capabilities associated with a given laboratory component.

MET 220L - Mineral Processing and Resource Recovery Lab

Laboratory exercises for these courses are carried out in MI 113, MI 126 and MI 130 of the Mineral Industry Building. Equipment and instrumentation are adequate for this laboratory. Some of the crushers, grinding units and flotation cells are relatively old, but all are in good condition to conduct undergraduate instruction. A new flotation cell, fume hood, jaw crusher, pH meter, and hot plate/stirrers have been added since the last ABET visit.

MET 231 - Structure and Properties of Materials Lab

Laboratory practices are conducted in MI 124, MI 125, MI 127A, MI 231, and MI 128B of the Mineral Industry Building. These rooms house sample mounting, grinding, polishing, imaging (image analyzer, SEM, TEM, optical microscopes) and mechanical property testing equipment (hardness testers, impact testers, tensile tester). A rolling mill is available in MI 125.

Significant equipment has either been purchased or upgraded since the last ABET visit. Specifically, the tensile tester has been upgraded with a new small capacity load cell. A new inverted metallurgical microscope with associated image analysis software has been purchased and is located in MI 128B. Two new polishing stations and a new abrasive cut-off saw have been added. Finally, new scanning electron microscope (SEM) has been acquired and is located in MI 231.

MET 310L – Aqueous Extraction, Concentration and Recycling Lab

Laboratory exercises for these courses are carried out in MI 113, MI 126, and MI 130 of the Mineral Industry Building. Equipment and instrumentation (zeta meter, electrochemical cells, contact angle goniometer, surface tensiometer) are adequate to conduct laboratory training. A new flotation cell, fume hood, and hot plate/stirrers have been added since the last ABET visit. In addition, a new rare earth magnetic separator has been added.

MET 330L - Physics of Metals Lab
Laboratory practices are conducted in MI 124, MI 125, MI 127A, MI 231, and MI 128B of the Mineral Industry Building. These rooms house sample mounting, grinding, polishing, imaging (image analyzer, SEM, optical microscopes) and mechanical property testing equipment (hardness testers, impact testers, tensile testers). Significant equipment has either been purchased or rebuilt since the last ABET visit. A rolling mill is available in MI 125.
Significant equipment has either been purchased or upgraded since the last ABET visit. Specifically, the tensile tester has been upgraded with a new small capacity load cell. A new inverted metallurgical microscope with associated image analysis software has been purchased and is located in MI 128B. Two new polishing stations and a new abrasive cut-off saw have been added. A new scanning electron microscope (MI 234) and a new x-ray diffractometer (MI 232) have been acquired.

MET 321L - High Temperature Extraction, Concentration, and Recycling
Laboratory exercises associated with this course are carried out in MI 128B and MI 121 of the Mineral Industry Building, as well as in the Foundry Laboratory. Electric furnaces, a gas muffle furnace, a bomb calorimeter, thermocouples, optical pyrometers and computers for data logging are used. Equipment used in this laboratory is, in general, adequate. Differential scanning calorimetry (DSC) equipment is located in MI 121. Since the last ABET visit, two new electric box furnaces and a vacuum melting furnace have been added.

MET 440L - Mechanical Metallurgy Lab
Equipment and instrumentation devices are housed in MI 124, MI 125 of the Mineral Industry Building and in the AMP extension of the Civil/Mechanical Building. Hardness testers, impact testers, tensile testers, electric furnaces and rolling mills are used in this course. New impact testing equipment (MI 125) and two new tensile/fatigue testers (located in the AMP) have been added to support the laboratory. Non-destructive testing equipment is sought, and local facilities are currently used for this purpose. (Ellsworth Air Force Base, Schoener Machine).

MET 430L – Welding Engineering and Design of Welded Structures
Equipment and facilities to support the welding lab are located in MI 124, MI 125 of the Mineral Industry Building and in the AMP extension of the Civil/Mechanical Building. The facilities include state-of-the-art fusion (gas and arc) welding equipment as well as solid-state (friction stir, friction stir spot, and ultrasonic) welding equipment. All of this equipment has been added since the last ABET visit.

Supplementary labs
Supplementary laboratory facilities that support classes that are not specifically lab based include-

- Corrosion Lab (MI 103A) – This lab supports activities in the MET 445 Oxidation and Corrosion of Metals class.
- X-ray diffraction Lab (MI 232) – This lab supports the MET 330 Physics of Metals and MET 465 Design classes.

Laboratory and research facilities in the Department of Materials and Metallurgical Engineering and support facilities, the AMP Center, and the Engineering and Mining Experiment Station have improved dramatically since the last visit. The department has upgraded many new pieces of equipment to support Metallurgical Engineering Program laboratory activities. Major new laboratory equipment acquisitions are summarized in Table 7-3. These purchases or upgrades involved approximately $7.6 million in funds. The Metallurgical Engineering program has long recognized that a viable program must continually modernize laboratories so as to provide students training and depth of study necessary to be competitive in a technical society. Table 7.4 shows a list of laboratory equipment acquired between 1998 and 2003 reported on the last ABET Self Study. A complete list of

existing laboratory equipment to support the Metallurgical Engineering program is given in Appendix C.

Laboratory Safety

Laboratory safety equipment has been upgraded or replaced in the majority of the labs along with placing of new signage. All labs contain readily-accessible first aid kits and fire extinguishers. Fume hoods have been replaced in the two main lab spaces that have chemical use (MI 124 and 126). Fume hoods in other labs are in good working order. New eyewash stations are located in the labs with chemical use (MI 121, 125, and 126). The shower to support these labs is located across from MI 124. New acid safety cabinets have been installed in all chemical labs.

Table 7-2
LABORATORY FACILITIES

Program: Metallurgical Engineering

Physical Facility Building and Room Number (1)	Purpose of Laboratory, Including Courses Taught	Condition of Laboratory (2)	Adequacy for Instruction	Number Student Per Year	Area (sq. ft.)
Mineral Industries Room 113	Particle size analysis: MET 220L, MET 310L	good	good	30	200
Mineral Industries Room 121	Differential scanning calorimeter: MET 321L	good	good	20	300
Mineral Industries Room 126	Solid/liquid separation, flotation, hydrometallurgy: MET 220L, MET 310L	good	good	30	1,140
Mineral Industries Room 130	Mineral processing, sample preparation: MET 220L, MET 310L, MET 321L	good	good	30	1,510
Mineral Industries Room 125	Mechanical testing: MET 231, MET 331, MET 440L	good	good	40	1,000
Mineral Industries Room 124	Atomic force microscopy, contact angle analysis: MET 231, MET 310L	good	good	40	400
Mineral Industries Room 124	Metallography: MET 231, MET 440L, MET 330L	good	good	40	945
Mineral Industries Room 234	SEM: MET 231, MET 330L, MET 440L	good	good	40	282
Mineral Industries Room 232	X-ray Diffraction: MET 330L, MET 465			30	412
Mineral Industries Room 128 B	High Temp Processes, Heat Treat: MET 231, MET 321L, MET 330L, MET 440	good	good	60	500
Mineral Industries Room 103A	Corrosion Lab: MET 445	good	good	15	128
Foundry Lab	Foundry, welding: MET 321L, MET 330L, MET 430L	good	good	15	1750
					TOTAL Area: 8,567

TABLE 7-3 Equipment and related software acquired or upgraded since 2004 for metallurgical engineering

Description	Cost ($K)
Materials Processing	
MTS ISTIR-10 3D Friction Stir Processing Equipment	2,500
MTS intelligent Laser Processing System (3 KW Nd: YAG laser, a Fanuc M16i Robot, and two feed systems)	1,500
RIFTEC Refill Friction Stir Spot Welding System	80
Cold Spot, Refill Friction Stir Spot Welding System	40
Centerline, SST Cold Spray System	90
Union/Szegvari Inc, Attrition Mill	8
Direct Write Lab (includes Maskless Mesoscale Material Deposition, Dimatix Ink Jet and nScrypt technology)	300
Hughes, 40 kW Induction Heating System	65
High frequency Sonicator	5
Ameritherm Induction heating system	40
Custom Thermoplastic Friction Stir Equipment	20
Dual-Reed Ultrasonic Welder	100
Centerline Cold Spray Unit	170
Jetline Automated MIG Seam Welder	75
Lincoln Electric Power MIG Welder	5
Big Blue Trip Hammer	8
Propane Forge	2
Coal forge (2)	1
Vacuum Melting Furnace	30
Jaw Crusher	5
Misc Blacksmithing Equipment	3
Carver hot press	15
Small Lindberg electric furnaces	4
Buehler polishing and grinding wheels	4
Fume hood (3)	8
Vacuum Oven	12
Flotation Cell	5
Rare Earth Magnetic Separator	18
Filter Press	2
Hot Plate/Stirrers (2)	1
Mechanical/Chemical Testing	
MTS 70 kip Universal Testing Machine	100
MTS 810 110 kip Material Test System	175
MTS 810 55 kip Material Test System	175
MTS 858 5.5 kip Material Test System	185
Tytron 250 Micro Mechanical Tester	150
RPM NJ1630 Mechanical Wear Testing	5
Alternate Immersion Corrosion Test Cell	10

TA Instruments, Q800 DMA	40
LECO, Interstitial Analyzer	55
LECO CS-600, Carbon/Sulfur Determinator	55
LECO TCH-600, Oxygen/Hydrogen/Nitrogen Determinator	55
Cryogenic Tensile Test Facility-20 kip attachment	5
Dynamic Projectile Impact Tester, 200 fps	5
MTS 50 lb force transducer/load cell	4
Upgraded software EG&G PARC model 273A potentiostat/galvanostat	3
Instron Instrumented Izod Impact Tester	25
Buehler Micromet 4 Microhardness Tester	20
Buehler Abrasimet Abrasive Cut-off Saw	5
Buehler Metallographic Sample Prep Equipment/Polisher Grinder	40
Mettler Toledo pH Meter	1
Analysis/Measurement	
Zeiss Supra 40 VP SEM—Field Emission	500
Nicomp 780 Surface Charge and Particle Size Analyzer	80
Phillips Macroscopic Image Analysis System	30
Rigaku Ultima Plus X-ray Diffraction System	250
Nikon Metallographic Microscope with Buehler Omnimet Image Analyzer	25
16-channel Data Acquisition Center	20
Tensiometer Goniometer	35
Misc Corrosion Equipment	3
Wilhelmy Plate Tensiometer	30
Bohlen Rheometer	30
Brookfield Viscometer	30
Omega Optical Pyrometer	1
Research Databases/Software	
SolidWorks, MathCad, LabView, DICTRA, THERMOCALC	25
Virtual Welding system	100
TEM computer upgrade	75
Total	**7,463**

***** If equipment acquired in the last ten years was not listed as new during the 2003 ABET visit, it is listed here.

Table 7-4 Equipment and related software acquired or upgraded between 1998-2003 for metallurgical engineering

Equipment	Cost ($K)
2 Mounting Presses (LECO)-new	5
Polishing Station (LECO)-new	5
Image Analyzer (LECO)-upgrade	30
FT-IR Spectrometer (Biorad)-new	150
Impact Tester (Instron)-new	20
Tensile Tester (MTS)-upgrade	25
DSC (TA Instruments)-new	60
TMA (TA Instruments)-new	60
Laser Particle Size Analyzer (Microtrac)-new	40
Portable Caster (custom)-new	10
Scanning Electron Microscope-upgraded	75
Box Furnace-new	3
Rame-Hart Contact Angle Goniometer	20
Hitachi H-7000 FA TEM	150
Total	**653**

Major support services for the B.S. metallurgical engineering program are the library, the Advanced Materials Processing (AMP) Laboratory, the Center for Advanced Manufacturing and Production (CAMP), and ITS (Instructional Technology Services). The support facilities have continued to improve since the last visit.

- The Metallurgical Engineering program is supported by the Devereaux Library. Responsibility for the Devereaux Library lies with the Director of the Library who reports to the Vice President for Academic Affairs. Although the library's holdings are somewhat limited, the availability of documents and research materials are adequate for undergraduate students and, in most cases, graduate students. The library staff is very helpful in promptly locating and obtaining interlibrary loans when needed. Our faculty and students are increasingly using the Internet and on-line journals for much of their information needs. Program funding for new purchases is adequate; however, the program could always use more. The Materials and Metallurgical Engineering Department along with the AMP Center purchase a yearly subscription to on-line version of the complete set The ASM Metals Handbook. A student library has been started in MI 105 that contains basic reference books on metallurgical engineering.
- The AMP Lab has proven very beneficial to student training. The AMP facility brings together highly specialized equipment in a laboratory environment to perform projects in Friction Stir Processing and Intelligent Laser Processing. These multidisciplinary projects (primarily senior design projects) often involve industrial partners, and government laboratories. In addition to use of equipment, AMP has provided adjunct faculty to teach topical courses of interest (MET 492-Friction Stir Processing).

- The CAMP Program has also proven very beneficial to student training. The CAMP program brings together students to work on multi-disciplinary senior design projects such as the Solar Rolar, Mini-Indy and Mini-Baja. These multi-disciplinary projects have proven to be superb design projects for students in our program.
- ITS provides distance learning services. The primary use of these services is for course taping when professors travel.

B. Resources and Support

The resources and support available to the program are described below.

1. Computing resources, hardware and software used for instruction.

Information and Technology Services (ITS) ITS provides both computer and distance learning assistance. Nearly all classrooms now have installed computer video projection equipment. In addition, ITS supports a 5 station PC bank (MI 105) for students in the program. Details on the campus network infrastructure, computing resources, and serves provided by Information Technology Services (ITS) is found in Appendix D, Section L. Non-Academic Supporting Units.

Computer services provided by ITS are primarily network services such as e-mail, Internet access, and file serving. The faculty and staff of the department primarily use Windows-based computers, which are supported by ITS. The ITS liaison for the MI building is Mr. Thomas Leonard (MI 120C). Mr. Leonard is trained to provide service on a variety of Windows-based operating systems and installations. The computer service personnel have always exhibited excellent expertise and desire to assist and will provide additional training to Mr. Leonard as needed.

2. Laboratory equipment planning, acquisition, and maintenance processes

In March 2005, the Board Regents approved a 22.3% increase in the fees for all laboratory courses taught at the School of Mines. Funds collected from laboratory fees are allocated in a manner that is determined to be most effective for the maintenance and upgrading of laboratories across campus. The provost receives 10% of all laboratory fees, and the remaining 90% is placed in a special account of the department that offers the course for which the fees were levied. The department head controls use of laboratory fee revenues. The provost typically redirects his 10% of laboratory fee revenues to the departments. In AY 2009-2010, the provost redistributed to the department heads $110,000 in laboratory fee revenues.

The construction of the Paleontology Research Laboratory (33,000 square feet) and the Chemical and Biological Engineering / Chemistry Building Addition (45,000 square feet) will be important contributions to the upgrading of instructional laboratories when these buildings are completed in the summer of 2010. The Paleontology Building will function primarily as a repository for the specimen collection and will house preparation, casting, and instructional laboratories for the paleontology program. The instructional laboratories now used for chemistry and for chemical and biological engineering will be replaced entirely by the new, state-of-the-

art laboratories in the new Chemical and Biological Engineering / Chemistry Building Addition.

To further support the ongoing maintenance and upgrading of laboratories and equipment, the allocation of "F&A funds" (i.e., the indirect costs charged to all externally funded programs) was revised in 2006, and again in 2009 after the elimination of the dean positions. The result is that the provost receives 10% of all indirect costs, the vice president for research receives 15% of indirect costs, the principal investigator (PI) of the externally funded program receives 10% of the indirect costs, and the department head of the program where the PI resides receives 10% of the indirect costs.

The provost and vice president for academic affairs collaborates with and seeks advice from the Materials and Metallurgical Engineering department about the best use of the recouped indirect costs in the budgets of the provost and the vice president for research. A technician and employees in the Physical Plant carry out the maintenance of the metallurgical equipment associated with this program. These people are responsible for the maintenance and repair of much of the equipment in the department. Work is handled through a work order system. Work is done on a priority basis with educational laboratory equipment receiving the highest priority. The equipment associated with this program is well maintained. Some of the equipment is old but is very serviceable and functional. Equipment that is no longer repairable is removed from service and replaced. Laboratory fees charged on all laboratory courses and campus technology fees provide funding for maintenance and equipment replacement. Research accounts are billed on an hourly basis for more specialized pieces of equipment. Equipment used through the campus Engineering and Mining Experiment Station also is maintained on an hourly use rate basis. The Materials and Metallurgical Engineering department has an ongoing plan to improve laboratory facilities. The department's plans focuses on 1) renovation of existing laboratory space, 2) maintaining existing equipment, and 3) acquisition of additional equipment. This has been our laboratory and program philosophy for the last decade. Great strides toward lab modernization have been made during the last decade. Our laboratories are structured to provide support to the engineering courses with increasing emphasis on multi-disciplinary team design projects. Funding of the laboratory plan rests upon continued state support of the program augmented by grants and contracts for research. Several recent research contracts and grants, including a recent NSF Course Curriculum Lab Improvement (CCLI) have resulted in significant lab upgrades. In addition, the Advanced Materials and Processing Lab has helped with the purchase and upgrade of several key pieces of equipment during the past few years.

The program faculty have identified the following needs for replacement and upgrading undergraduate laboratory equipment for the Metallurgical Engineering undergraduate program. The equipment to be replaced or upgraded, in order of priority is listed below.

1. Software upgrade for the MTS tensile testing system in MI-125. This software system is outdated; however, the hardware is in good working order. The estimated cost to upgrade this software system for an educational institution is approximately $7,000.
2. The "Buehler Manual Polishing Wheels" are in poor working condition. Even though this polishing system is out dated equipment, and is no longer used in industry, the experience students' gain using hand polishing is useful. Upgrading the hand polishing wheels will cost approximately $15,000. However, an upgrade to a modern semi-automatic polishing system can be accomplished for $25,000.
3. Upgrade the extensometer system for the MTS tensile tester. The current extensometer is inconsistent and occasionally does not record the data. The estimated cost for this component is approximately $5,000.
4. The Mineral Processing Laboratory needs to upgrade the heavy media separator for an approximate cost of $20,000.
5. The Mineral Processing Laboratory also needs three floatation cell replacements at an estimated cost of $10,000 each ($30,000 total).
6. The Mineral Processing Laboratory also needs an electrostatic separator at an estimated cost of $30,000.

Total estimated cost: $107,000 to $132,000.

3. Support personnel available to install, maintain, and manage departmental hardware, software, and networks

One full-time computer and laboratory support specialist (Mr. Thomas Leonard) is available to support and maintain departmental hardware. Campus network infrastructure and computing resources are also directly supported by Information and Technology Services (ITS). Details of services provided by ITS are found in Appendix D, Section L.

4. Support personnel available to install, maintain, and manage laboratory equipment.

One full-time computer and laboratory support specialist (Mr. Thomas Leonard) is available to support and maintain laboratory equipment. In addition, one full time engineer (Mr. Todd Curtis) is available to install and manage laboratory equipment associated with the Advanced Materials Processing Center. Major equipment issues are also supported by the campus Physical Plant.

C. Major Instructional and Laboratory Equipment

Appendix C lists all of all major equipment avail to the program.