中华人民共和国职业病防治法

（2001 年 10 月 27 日第九届全国人民代表大会常务委员会第二十四次会议通过　根据 2011 年 12 月 31 日第十一届全国人民代表大会常务委员会第二十四次会议《关于修改<中华人民共和国职业病防治法>的决定》修正）

第一章　总则

第一条　为了预防、控制和消除职业病危害，防治职业病，保护劳动者健康及其相关权益，促进经济社会发展，根据宪法，制定本法。

第二条　本法适用于中华人民共和国领域内的职业病防治活动。

本法所称职业病，是指企业、事业单位和个体经济组织等用人单位的劳动者在职业活动中，因接触粉尘、放射性物质和其他有毒、有害因素而引起的疾病。

职业病的分类和目录由国务院卫生行政部门会同国务院安全生产监督管理部门、劳动保障行政部门制定、调整并公布。

第三条　职业病防治工作坚持预防为主、防治结合的方针，建立用人单位负责、行政机关监管、行业自律、职工参与和社会监督的机制，实行分类管理、综合治理。

第四条　劳动者依法享有职业卫生保护的权利。

用人单位应当为劳动者创造符合国家职业卫生标准和卫生要求的工作环境和条件，并采取措施保障劳动者获得职业卫生保护。

工会组织依法对职业病防治工作进行监督，维护劳动者的合法权益。用人单位制定或者修改有关职业病防治的规章制度，应当听取工会组织的意见。

第五条　用人单位应当建立、健全职业病防治责任制，加强对职业病防治的管理，提高职业病防治水平，对本单位产生的职业病危害承担责任。

第六条　用人单位的主要负责人对本单位的职业病防治工作全面负责。

第七条　用人单位必须依法参加工伤保险。

国务院和县级以上地方人民政府劳动保障行政部门应当加强对工伤保险的监督管理，确保劳动者依法享受工伤保险待遇。

第八条　国家鼓励和支持研制、开发、推广、应用有利于职业病防治和保护劳动者健康的新技术、新工艺、新设备、新材料，加强对职业病的机理和发生规律的基础研究，提高职业病防治科学技术水平；积极采用有效的职业病防治技术、工艺、设备、材料；限制使用或者淘汰职业病危害严重的技术、工艺、设备、材料。

国家鼓励和支持职业病医疗康复机构的建设。

第九条　国家实行职业卫生监督制度。

国务院安全生产监督管理部门、卫生行政部门、劳动保障行政部门依照本法和国务院确定的职责，负责全国职业病防治的监督管理工作。国务院有关部门在各自的职责范围内负责职业病防治的有关监督管理工作。

县级以上地方人民政府安全生产监督管理部门、卫生行政部门、劳动保障行政部门依据各自职责，负责本行政区域内职业病防治的监督管理工作。县级以上地方人民政府有关部门在各自的职责范围内负责职业病防治的有关监督管理工作。

县级以上人民政府安全生产监督管理部门、卫生行政部门、劳动保障行政部门（以下统称职业卫生监督管理部门）应当加强沟通，密切配合，按照各自职责分工，依法行使职权，承担责任。

第十条　国务院和县级以上地方人民政府应当制定职业病防治规划，将其纳入国民经济和社会发展计划，并组织实施。

县级以上地方人民政府统一负责、领导、组织、协调本行政区域的职业病防治工作，建立健全职业病防治工作体制、机制，统一领导、指挥职业卫生突发事件应对工作；加强职业病防治能力建设和服务体系建设，完善、落实职业病防治工作责任制。

乡、民族乡、镇的人民政府应当认真执行本法，支持职业卫生监督管理部门依法履行职责。

第十一条　县级以上人民政府职业卫生监督管理部门应当加强对职业病防治的宣传教育，普及职业病防治的知识，增强用人单位的职业病防治观念，提高劳动者的职业健康意识、自我保护意识和行使职业卫生保护权利的能力。

第十二条　有关防治职业病的国家职业卫生标准，由国务院卫生行政部门组织制定并公布。

国务院卫生行政部门应当组织开展重点职业病监测和专项调查，对职业健康风险进行评估，为制定职业卫生标准和职业病防治政策提供科学依据。

县级以上地方人民政府卫生行政部门应当定期对本行政区域的职业病防治情况进行统计和调查分析。

第十三条　任何单位和个人有权对违反本法的行为进行检举和控告。有关部门收到相关的检举和控告后，应当及时处理。

对防治职业病成绩显著的单位和个人，给予奖励。

第二章　前期预防

第十四条　用人单位应当依照法律、法规要求，严格遵守国家职业卫生标准，落实职业病预防措施，从源头上控制和消除职业病危害。

第十五条　产生职业病危害的用人单位的设立除应当符合法律、行政法规规定的设立条件外，其工作场所还应当符合下列职业卫生要求：

（一）职业病危害因素的强度或者浓度符合国家职业卫生标准；

（二）有与职业病危害防护相适应的设施；

（三）生产布局合理，符合有害与无害作业分开的原则；

（四）有配套的更衣间、洗浴间、孕妇休息间等卫生设施；

（五）设备、工具、用具等设施符合保护劳动者生理、心理健康的要求；

（六）法律、行政法规和国务院卫生行政部门、安全生产监督管理部门关于保护劳动者健康的其他要求。

第十六条　国家建立职业病危害项目申报制度。

用人单位工作场所存在职业病目录所列职业病的危害因素的，应当及时、如实向所在地安全生产监督管理部门申报危害项目，接受监督。

职业病危害因素分类目录由国务院卫生行政部门会同国务院安全生产监督管理部门制定、调整并公布。职业病危害项目申报的具体办法由国务院安全生产监督管理部门制定。

第十七条　新建、扩建、改建建设项目和技术改造、技术引进项目（以下统称建设项目）可能产生职业病危害的，建设单位在可行性论证阶段应当向安全生产监督管理部门提交职业病危害预评价报告。安全生产监督管理部门应当自收到职业病危害预评价报告之日起三十日内，作出审核决定并书面通知建设单位。未提交预评价报告或者预评价报告未经安全生产监督管理部门审核同意的，有关部门不得批准该建设项目。

职业病危害预评价报告应当对建设项目可能产生的职业病危害因素及其对工作场所和劳动者健康的影响作出评价，确定危害类别和职业病防护措施。

建设项目职业病危害分类管理办法由国务院安全生产监督管理部门制定。

第十八条　建设项目的职业病防护设施所需费用应当纳入建设项目工程预算，并与主体工程同时设计，同时施工，同时投入生产和使用。

职业病危害严重的建设项目的防护设施设计，应当经安全生产监督管理部门审查，符合国家职业卫生标准和卫生要求的，方可施工。

建设项目在竣工验收前，建设单位应当进行职业病危害控制效果评价。建设项目竣工验收时，其职业病防护设施经安全生产监督管理部门验收合格后，方可投入正式生产和使用。

第十九条　职业病危害预评价、职业病危害控制效果评价由依法设立的取得国务院安全生产监督管理部门或者设区的市级以上地方人民政府安全生产监督管理部门按照职责分工给予资质认可的职业卫生技术服务机构进行。职业卫生技术服务机构所作评价应当客观、真实。

第二十条　国家对从事放射性、高毒、高危粉尘等作业实行特殊管理。具体管理办法由国务院制定。

第三章　劳动过程中的防护与管理

第二十一条　用人单位应当采取下列职业病防治管理措施:

（一）设置或者指定职业卫生管理机构或者组织，配备专职或者兼职的职业卫生管理人员，负责本单位的职业病防治工作；

（二）制定职业病防治计划和实施方案；

（三）建立、健全职业卫生管理制度和操作规程；

（四）建立、健全职业卫生档案和劳动者健康监护档案；

（五）建立、健全工作场所职业病危害因素监测及评价制度；

（六）建立、健全职业病危害事故应急救援预案。

第二十二条　用人单位应当保障职业病防治所需的资金投入，不得挤占、挪用，并对因资金投入不足导致的后果承担责任。

第二十三条　用人单位必须采用有效的职业病防护设施，并为劳动者提供个人使用的职业病防护用品。

用人单位为劳动者个人提供的职业病防护用品必须符合防治职业病的要求；不符合要求的，不得使用。

第二十四条　用人单位应当优先采用有利于防治职业病和保护劳动者健康的新技术、新工艺、新设备、新材料，逐步替代职业病危害严重的技术、工艺、设备、材料。

第二十五条　产生职业病危害的用人单位，应当在醒目位置设置公告栏，公布有关职业病防治的规章制度、操作规程、职业病危害事故应急救援措施和工作场所职业病危害因素检测结果。

对产生严重职业病危害的作业岗位，应当在其醒目位置，设置警示标识和中文警示说明。警示说明应当载明产生职业病危害的种类、后果、预防以及应急救治措施等内容。

第二十六条　对可能发生急性职业损伤的有毒、有害工作场所，用人单位应当设置报警装置，配置现场急救用品、冲洗设备、应急撤离通道和必要的泄险区。

对放射工作场所和放射性同位素的运输、贮存，用人单位必须配置防护设备和报警装置，保证接触放射线的工作人员佩戴个人剂量计。

对职业病防护设备、应急救援设施和个人使用的职业病防护用品，用人单位应当进行经常性的维护、检修，定期检测其性能和效果，确保其处于正常状态，不得擅自拆除或者停止使用。

第二十七条　用人单位应当实施由专人负责的职业病危害因素日常监测，并确保监测系统处于正常运行状态。

用人单位应当按照国务院安全生产监督管理部门的规定，定期对工作场所进行职业病危害因素检测、评价。检测、评价结果存入用人单位职业卫生档案，定期向所在地安全生产监督管理部门报告并向劳动者公布。

职业病危害因素检测、评价由依法设立的取得国务院安全生产监督管理部门或者设区的市级以上地方人民政府安全生产监督管理部门按照职责分工给予资质认可的职业卫生技术服务机构进行。职业卫生技术服务机构所作检测、评价应当客观、真实。

发现工作场所职业病危害因素不符合国家职业卫生标准和卫生要求时，用人单位应当立即采取相应治理措施，仍然达不到国家职业卫生标准和卫生要求的，必须停止存在职业病危害因素的作业；职业病危害因素经治理后，符合国家职业卫生标准和卫生要求的，方可重新作业。

第二十八条　职业卫生技术服务机构依法从事职业病危害因素检测、评价工作，接受安全生产监督管理部门的监督检查。安全生产监督管理部门应当依法履行监督职责。

第二十九条　向用人单位提供可能产生职业病危害的设备的，应当提供中文说明书，并在设备的醒目位置设置警示标识和中文警示说明。警示说明应当载明设备性能、可能产生的职业病危害、安全操作和维护注意事项、职业病防护以及应急救治措施等内容。

第三十条　向用人单位提供可能产生职业病危害的化学品、放射性同位素和含有放射性物质的材料的，应当提供中文说明书。说明书应当载明产品特性、主要成份、存在的有害因素、可能产生的危害后果、安全使用注意事项、职业病防护以及应急救治措施等内容。产品包装应当有醒目的警示标识和中文警示说明。贮存上述材料的场所应当在规定的部位设置危险物品标识或

者放射性警示标识。

国内首次使用或者首次进口与职业病危害有关的化学材料，使用单位或者进口单位按照国家规定经国务院有关部门批准后，应当向国务院卫生行政部门、安全生产监督管理部门报送该化学材料的毒性鉴定以及经有关部门登记注册或者批准进口的文件等资料。

进口放射性同位素、射线装置和含有放射性物质的物品的，按照国家有关规定办理。

第三十一条　任何单位和个人不得生产、经营、进口和使用国家明令禁止使用的可能产生职业病危害的设备或者材料。

第三十二条　任何单位和个人不得将产生职业病危害的作业转移给不具备职业病防护条件的单位和个人。不具备职业病防护条件的单位和个人不得接受产生职业病危害的作业。

第三十三条　用人单位对采用的技术、工艺、设备、材料，应当知悉其产生的职业病危害，对有职业病危害的技术、工艺、设备、材料隐瞒其危害而采用的，对所造成的职业病危害后果承担责任。

第三十四条　用人单位与劳动者订立劳动合同（含聘用合同，下同）时，应当将工作过程中可能产生的职业病危害及其后果、职业病防护措施和待遇等如实告知劳动者，并在劳动合同中写明，不得隐瞒或者欺骗。

劳动者在已订立劳动合同期间因工作岗位或者工作内容变更，从事与所订立劳动合同中未告知的存在职业病危害的作业时，用人单位应当依照前款规定，向劳动者履行如实告知的义务，并协商变更原劳动合同相关条款。

用人单位违反前两款规定的，劳动者有权拒绝从事存在职业病危害的作业，用人单位不得因此解除与劳动者所订立的劳动合同。

第三十五条　用人单位的主要负责人和职业卫生管理人员应当接受职业卫生培训，遵守职业病防治法律、法规，依法组织本单位的职业病防治工作。

用人单位应当对劳动者进行上岗前的职业卫生培训和在岗期间的定期职业卫生培训，普及职业卫生知识，督促劳动者遵守职业病防治法律、法规、规章和操作规程，指导劳动者正确使用职业病防护设备和个人使用的职业病防护用品。

劳动者应当学习和掌握相关的职业卫生知识，增强职业病防范意识，遵守职业病防治法律、法规、规章和操作规程，正确使用、维护职业病防护设备和个人使用的职业病防护用品，发现职业病危害事故隐患应当及时报告。

劳动者不履行前款规定义务的，用人单位应当对其进行教育。

第三十六条　对从事接触职业病危害的作业的劳动者，用人单位应当按照国务院安全生产监督管理部门、卫生行政部门的规定组织上岗前、在岗期间和离岗时的职业健康检查，并将检查结果书面告知劳动者。职业健康检查费用由用人单位承担。

用人单位不得安排未经上岗前职业健康检查的劳动者从事接触职业病危害的作业；不得安排有职业禁忌的劳动者从事其所禁忌的作业；对在职业健康检查中发现有与所从事的职业相关的健康损害的劳动者，应当调离原工作岗位，并妥善安置；对未进行离岗前职业健康检查的劳动者不得解除或者终止与其订立的劳动合同。

职业健康检查应当由省级以上人民政府卫生行政部门批准的医疗卫生机构承担。

第三十七条　用人单位应当为劳动者建立职业健康监护档案，并按照规定的期限妥善保存。

职业健康监护档案应当包括劳动者的职业史、职业病危害接触史、职业健康检查结果和职业病诊疗等有关个人健康资料。

劳动者离开用人单位时，有权索取本人职业健康监护档案复印件，用人单位应当如实、无偿提供，并在所提供的复印件上签章。

第三十八条　发生或者可能发生急性职业病危害事故时，用人单位应当立即采取应急救援和控制措施，并及时报告所在地安全生产监督管理部门和有关部门。安全生产监督管理部门接到报告后，应当及时会同有关部门组织调查处理；必要时，可以采取临时控制措施。卫生行政部门应当组织做好医疗救治工作。

对遭受或者可能遭受急性职业病危害的劳动者，用人单位应当及时组织救治、进行健康检查和医学观察，所需费用由用人单位承担。

第三十九条　用人单位不得安排未成年工从事接触职业病危害的作业；不得安排孕期、哺乳期的女职工从事对本人和胎儿、婴儿有危害的作业。

第四十条　劳动者享有下列职业卫生保护权利：

（一）获得职业卫生教育、培训；

（二）获得职业健康检查、职业病诊疗、康复等职业病防治服务；

（三）了解工作场所产生或者可能产生的职业病危害因素、危害后果和应当采取的职业病防护措施；

（四）要求用人单位提供符合防治职业病要求的职业病防护设施和个人使用的职业病防护用品，改善工作条件；

（五）对违反职业病防治法律、法规以及危及生命健康的行为提出批评、检举和控告；

（六）拒绝违章指挥和强令进行没有职业病防护措施的作业；

（七）参与用人单位职业卫生工作的民主管理，对职业病防治工作提出意见和建议。

用人单位应当保障劳动者行使前款所列权利。因劳动者依法行使正当权利而降低其工资、福利等待遇或者解除、终止与其订立的劳动合同的，其行为无效。

第四十一条　工会组织应当督促并协助用人单位开展职业卫生宣传教育和培训，有权对用人单位的职业病防治工作提出意见和建议，依法代表劳动者与用人单位签订劳动安全卫生专项集体合同，与用人单位就劳动者反映的有关职业病防治的问题进行协调并督促解决。

工会组织对用人单位违反职业病防治法律、法规，侵犯劳动者合法权益的行为，有权要求纠正；产生严重职业病危害时，有权要求采取防护措施，或者向政府有关部门建议采取强制性措施；发生职业病危害事故时，有权参与事故调查处理；发现危及劳动者生命健康的情形时，有权向用人单位建议组织劳动者撤离危险现场，用人单位应当立即作出处理。

第四十二条　用人单位按照职业病防治要求，用于预防和治理职业病危害、工作场所卫生检测、健康监护和职业卫生培训等费用，按照国家有关规定，在生产成本中据实列支。

第四十三条　职业卫生监督管理部门应当按照职责分工，加强对用人单位落实职业病防护管理措施情况的监督检查，依法行使职权，承担责任。

第四章　职业病诊断与职业病病人保障

第四十四条　医疗卫生机构承担职业病诊断，应当经省、自治区、直辖市人民政府卫生行政部门批准。省、自治区、直辖市人民政府卫生行政部门应当向社会公布本行政区域内承担职业病诊断的医疗卫生机构的名单。

承担职业病诊断的医疗卫生机构应当具备下列条件:

（一）持有《医疗机构执业许可证》；

（二）具有与开展职业病诊断相适应的医疗卫生技术人员；

（三）具有与开展职业病诊断相适应的仪器、设备；

（四）具有健全的职业病诊断质量管理制度。

承担职业病诊断的医疗卫生机构不得拒绝劳动者进行职业病诊断的要求。

第四十五条　劳动者可以在用人单位所在地、本人户籍所在地或者经常居住地依法承担职业病诊断的医疗卫生机构进行职业病诊断。

第四十六条　职业病诊断标准和职业病诊断、鉴定办法由国务院卫生行政部门制定。职业病伤残等级的鉴定办法由国务院劳动保障行政部门会同国务院卫生行政部门制定。

第四十七条　职业病诊断，应当综合分析下列因素:

（一）病人的职业史；

（二）职业病危害接触史和工作场所职业病危害因素情况；

（三）临床表现以及辅助检查结果等。

没有证据否定职业病危害因素与病人临床表现之间的必然联系的，应当诊断为职业病。

承担职业病诊断的医疗卫生机构在进行职业病诊断时，应当组织三名以上取得职业病诊断资格的执业医师集体诊断。

职业病诊断证明书应当由参与诊断的医师共同签署，并经承担职业病诊断的医疗卫生机构审核盖章。

第四十八条　用人单位应当如实提供职业病诊断、鉴定所需的劳动者职业史和职业病危害接触史、工作场所职业病危害因素检测结果等资料；安全生产监督管理部门应当监督检查和督促用人单位提供上述资料；劳动者和有关机构也应当提供与职业病诊断、鉴定有关的资料。

职业病诊断、鉴定机构需要了解工作场所职业病危害因素情况时，可以对工作场所进行现场调查，也可以向安全生产监督管理部门提出，安全生产监督管理部门应当在十日内组织现场调查。用人单位不得拒绝、阻挠。

第四十九条　职业病诊断、鉴定过程中，用人单位不提供工作场所职业病危害因素检测结果等资料的，诊断、鉴定机构应当结合劳动者的临床表现、辅助检查结果和劳动者的职业史、职业病危害接触史，并参考劳动者的自述、安全生产监督管理部门提供的日常监督检查信息等，作出职业病诊断、鉴定结论。

劳动者对用人单位提供的工作场所职业病危害因素检测结果等资料有异议，或者因劳动者的用人单位解散、破产，无用人单位提供上述资料的，诊断、鉴定机构应当提请安全生产监督管理部门进行调查，安全生产监督管理部门应当自接到申请之日起三十日内对存在异议的资料或者工作场所职业病危害因素情况作出判定；有关部门应当配合。

第五十条　职业病诊断、鉴定过程中，在确认劳动者职业史、职业病危害接触史时，当事人对劳动关系、工种、工作岗位或者在岗时间有争议的，可以向当地的劳动人事争议仲裁委员会申请仲裁；接到申请的劳动人事争议仲裁委员会应当受理，并在三十日内作出裁决。

当事人在仲裁过程中对自己提出的主张，有责任提供证据。劳动者无法提供由用人单位掌握管理的与仲裁主张有关的证据的，仲裁庭应当要求用人单位在指定期限内提供；用人单位在指定期限内不提供的，应当承担不利后果。

劳动者对仲裁裁决不服的，可以依法向人民法院提起诉讼。

用人单位对仲裁裁决不服的，可以在职业病诊断、鉴定程序结束之日起十五日内依法向人民法院提起诉讼；诉讼期间，劳动者的治疗费用按照职业病待遇规定的途径支付。

第五十一条　用人单位和医疗卫生机构发现职业病病人或者疑似职业病病人时，应当及时向所在地卫生行政部门和安全生产监督管理部门报告。确诊为职业病的，用人单位还应当向所在地劳动保障行政部门报告。接到报告的部门应当依法作出处理。

第五十二条　县级以上地方人民政府卫生行政部门负责本行政区域内的职业病统计报告的管理工作，并按照规定上报。

第五十三条　当事人对职业病诊断有异议的，可以向作出诊断的医疗卫生机构所在地地方人民政府卫生行政部门申请鉴定。

职业病诊断争议由设区的市级以上地方人民政府卫生行政部门根据当事人的申请，组织职业病诊断鉴定委员会进行鉴定。

当事人对设区的市级职业病诊断鉴定委员会的鉴定结论不服的，可以向省、自治区、直辖市人民政府卫生行政部门申请再鉴定。

第五十四条　职业病诊断鉴定委员会由相关专业的专家组成。

省、自治区、直辖市人民政府卫生行政部门应当设立相关的专家库，需要对职业病争议作出诊断鉴定时，由当事人或者当事人委托有关卫生行政部门从专家库中以随机抽取的方式确定参加诊断鉴定委员会的专家。

职业病诊断鉴定委员会应当按照国务院卫生行政部门颁布的职业病诊断标准和职业病诊断、鉴定办法进行职业病诊断鉴定，向当事人出具职业病诊断鉴定书。职业病诊断、鉴定费用由用人单位承担。

第五十五条　职业病诊断鉴定委员会组成人员应当遵守职业道德，客观、公正地进行诊断鉴定，并承担相应的责任。职业病诊断鉴定委员会组成人员不得私下接触当事人，不得收受当事人的财物或者其他好处，与当事人有利害关系的，应当回避。

人民法院受理有关案件需要进行职业病鉴定时，应当从省、自治区、直辖市人民政府卫生行政部门依法设立的相关的专家库中选取参加鉴定的专家。

第五十六条　医疗卫生机构发现疑似职业病病人时，应当告知劳动者本人并及时通知用人单位。

用人单位应当及时安排对疑似职业病病人进行诊断；在疑似职业病病人诊断或者医学观察期间，不得解除或者终止与其订立的劳动合同。

疑似职业病病人在诊断、医学观察期间的费用，由用人单位承担。

第五十七条　用人单位应当保障职业病病人依法享受国家规定的职业病待遇。

用人单位应当按照国家有关规定，安排职业病病人进行治疗、康复和定期检查。

用人单位对不适宜继续从事原工作的职业病病人，应当调离原岗位，并妥善安置。

用人单位对从事接触职业病危害的作业的劳动者，应当给予适当岗位津贴。

第五十八条　职业病病人的诊疗、康复费用，伤残以及丧失劳动能力的职业病病人的社会保障，按照国家有关工伤保险的规定执行。

第五十九条　职业病病人除依法享有工伤保险外，依照有关民事法律，尚有获得赔偿的权利的，有权向用人单位提出赔偿要求。

第六十条　劳动者被诊断患有职业病，但用人单位没有依法参加工伤保险的，其医疗和生活保障由该用人单位承担。

第六十一条　职业病病人变动工作单位，其依法享有的待遇不变。

用人单位在发生分立、合并、解散、破产等情形时，应当对从事接触职业病危害的作业的劳动者进行健康检查，并按照国家有关规定妥善安置职业病病人。

第六十二条　用人单位已经不存在或者无法确认劳动关系的职业病病人，可以向地方人民政府民政部门申请医疗救助和生活等方面的救助。

地方各级人民政府应当根据本地区的实际情况，采取其他措施，使前款规定的职业病病人获得医疗救治。

第五章　监督检查

第六十三条　县级以上人民政府职业卫生监督管理部门依照职业病防治法律、法规、国家职业卫生标准和卫生要求，依据职责划分，对职业病防治工作进行监督检查。

第六十四条　安全生产监督管理部门履行监督检查职责时，有权采取下列措施:

（一）进入被检查单位和职业病危害现场，了解情况，调查取证；

（二）查阅或者复制与违反职业病防治法律、法规的行为有关的资料和采集样品；

（三）责令违反职业病防治法律、法规的单位和个人停止违法行为。

第六十五条　发生职业病危害事故或者有证据证明危害状态可能导致职业病危害事故发生时，安全生产监督管理部门可以采取下列临时控制措施:

（一）责令暂停导致职业病危害事故的作业；

（二）封存造成职业病危害事故或者可能导致职业病危害事故发生的材料和设备；

（三）组织控制职业病危害事故现场。

在职业病危害事故或者危害状态得到有效控制后，安全生产监督管理部门应当及时解除控制措施。

第六十六条　职业卫生监督执法人员依法执行职务时，应当出示监督执法证件。

职业卫生监督执法人员应当忠于职守，秉公执法，严格遵守执法规范；涉及用人单位的秘密的，应当为其保密。

第六十七条　职业卫生监督执法人员依法执行职务时，被检查单位应当接受检查并予以支持配合，不得拒绝和阻碍。

第六十八条　安全生产监督管理部门及其职业卫生监督执法人员履行职责时，不得有下列行为:

（一）对不符合法定条件的，发给建设项目有关证明文件、资质证明文件或者予以批准；

（二）对已经取得有关证明文件的，不履行监督检查职责；

（三）发现用人单位存在职业病危害的，可能造成职业病危害事故，不及时依法采取控制措施；

（四）其他违反本法的行为。

第六十九条　职业卫生监督执法人员应当依法经过资格认定。

职业卫生监督管理部门应当加强队伍建设，提高职业卫生监督执法人员的政治、业务素质，依照本法和其他有关法律、法规的规定，建立、健全内部监督制度，对其工作人员执行法律、法规和遵守纪律的情况，进行监督检查。

第六章　法律责任

第七十条　建设单位违反本法规定，有下列行为之一的，由安全生产监督管理部门给予警告，责令限期改正；逾期不改正的，处十万元以上五十万元以下的罚款；情节严重的，责令停止产生职业病危害的作业，或者提请有关人民政府按照国务院规定的权限责令停建、关闭:

（一）未按照规定进行职业病危害预评价或者未提交职业病危害预评价报告，或者职业病危害预评价报告未经安全生产监督管理部门审核同意，开工建设的；

（二）建设项目的职业病防护设施未按照规定与主体工程同时投入生产和使用的；

（三）职业病危害严重的建设项目，其职业病防护设施设计未经安全生产监督管理部门审查，或者不符合国家职业卫生标准和卫生要求施工的；

（四）未按照规定对职业病防护设施进行职业病危害控制效果评价、未经安全生产监督管理部门验收或者验收不合格，擅自投入使用的。

第七十一条　违反本法规定，有下列行为之一的，由安全生产监督管理部门给予警告，责令限期改正；逾期不改正的，处十万元以下的罚款:

（一）工作场所职业病危害因素检测、评价结果没有存档、上报、公布的；

（二）未采取本法第二十一条规定的职业病防治管理措施的；

（三）未按照规定公布有关职业病防治的规章制度、操作规程、职业病危害事故应急救援措施的；

（四）未按照规定组织劳动者进行职业卫生培训，或者未对劳动者个人职业病防护采取指导、督促措施的；

（五）国内首次使用或者首次进口与职业病危害有关的化学材料，未按照规定报送毒性鉴定资料以及经有关部门登记注册或者批准进口的文件的。

第七十二条　用人单位违反本法规定，有下列行为之一的，由安全生产监督管理部门责令限期改正，给予警告，可以并处五万元以上十万元以下的罚款:

（一）未按照规定及时、如实向安全生产监督管理部门申报产生职业病危害的项目的；

（二）未实施由专人负责的职业病危害因素日常监测，或者监测系统不能正常监测的；

（三）订立或者变更劳动合同时，未告知劳动者职业病危害真实情况的；

（四）未按照规定组织职业健康检查、建立职业健康监护档案或者未将检查结果书面告知劳动者的；

（五）未依照本法规定在劳动者离开用人单位时提供职业健康监护档案复印件的。

第七十三条　用人单位违反本法规定，有下列行为之一的，由安全生产监督管理部门给予警告，责令限期改正，逾期不改正的，处五万元以上二十万元以下的罚款；情节严重的，责令停止产生职业病危害的作业，或者提请有关人民政府按照国务院规定的权限责令关闭:

（一）工作场所职业病危害因素的强度或者浓度超过国家职业卫生标准的；

（二）未提供职业病防护设施和个人使用的职业病防护用品，或者提供的职业病防护设施和个人使用的职业病防护用品不符合国家职业卫生标准和卫生要求的；

（三）对职业病防护设备、应急救援设施和个人使用的职业病防护用品未按照规定进行维护、检修、检测，或者不能保持正常运行、使用状态的；

（四）未按照规定对工作场所职业病危害因素进行检测、评价的；

（五）工作场所职业病危害因素经治理仍然达不到国家职业卫生标准和卫生要求时，未停止存在职业病危害因素的作业的；

（六）未按照规定安排职业病病人、疑似职业病病人进行诊治的；

（七）发生或者可能发生急性职业病危害事故时，未立即采取应急救援和控制措施或者未按照规定及时报告的；

（八）未按照规定在产生严重职业病危害的作业岗位醒目位置设置警示标识和中文警示说明的；

（九）拒绝职业卫生监督管理部门监督检查的；

（十）隐瞒、伪造、篡改、毁损职业健康监护档案、工作场所职业病危害因素检测评价结果等相关资料，或者拒不提供职业病诊断、鉴定所需资料的；

（十一）未按照规定承担职业病诊断、鉴定费用和职业病病人的医疗、生活保障费用的。

第七十四条　向用人单位提供可能产生职业病危害的设备、材料，未按照规定提供中文说明书或者设置警示标识和中文警示说明的，由安全生产监督管理部门责令限期改正，给予警告，并处五万元以上二十万元以下的罚款。

第七十五条　用人单位和医疗卫生机构未按照规定报告职业病、疑似职业病的，由有关主管部门依据职责分工责令限期改正，给予警告，可以并处一万元以下的罚款；弄虚作假的，并处二万元以上五万元以下的罚款；对直接负责的主管人员和其他直接责任人员，可以依法给予降级或者撤职的处分。

第七十六条　违反本法规定，有下列情形之一的，由安全生产监督管理部门责令限期治理，并处五万元以上三十万元以下的罚款；情节严重的，责令停止产生职业病危害的作业，或者提请有关人民政府按照国务院规定的权限责令关闭:

（一）隐瞒技术、工艺、设备、材料所产生的职业病危害而采用的；

（二）隐瞒本单位职业卫生真实情况的；

（三）可能发生急性职业损伤的有毒、有害工作场所、放射工作场所或者放射性同位素的运输、贮存不符合本法第二十六条规定的；

（四）使用国家明令禁止使用的可能产生职业病危害的设备或者材料的；

（五）将产生职业病危害的作业转移给没有职业病防护条件的单位和个人，或者没有职业病防护条件的单位和个人接受产生职业病危害的作业的；

（六）擅自拆除、停止使用职业病防护设备或者应急救援设施的；

（七）安排未经职业健康检查的劳动者、有职业禁忌的劳动者、未成年工或者孕期、哺乳期女职工从事接触职业病危害的作业或者禁忌作业的；

（八）违章指挥和强令劳动者进行没有职业病防护措施的作业的。

第七十七条　生产、经营或者进口国家明令禁止使用的可能产生职业病危害的设备或者材料的，依照有关法律、行政法规的规定给予处罚。

第七十八条　用人单位违反本法规定，已经对劳动者生命健康造成严重损害的，由安全生产监督管理部门责令停止产生职业病危害的作业，或者提请有关人民政府按照国务院规定的权限责令关闭，并处十万元以上五十万元以下的罚款。

第七十九条　用人单位违反本法规定，造成重大职业病危害事故或者其他严重后果，构成犯罪的，对直接负责的主管人员和其他直接责任人员，依法追究刑事责任。

第八十条　未取得职业卫生技术服务资质认可擅自从事职业卫生技术服务的，或者医疗卫生机构未经批准擅自从事职业健康检查、职业病诊断的，由安全生产监督管理部门和卫生行政部门依据职责分工责令立即停止违法行为，没收违法所得；违法所得五千元以上的，并处违法所得二倍以上十倍以下的罚款；没有违法所得或者违法所得不足五千元的，并处五千元以上五万元以下的罚款；情节严重的，对直接负责的主管人员和其他直接责任人员，依法给予降级、撤职或者开除的处分。

第八十一条　从事职业卫生技术服务的机构和承担职业健康检查、职业病诊断的医疗卫生机构违反本法规定，有下列行为之一的，由安全生产监督管理部门和卫生行政部门依据职责分工责令立即停止违法行为，给予警告，没收违法所得；违法所得五千元以上的，并处违法所得二倍以上五倍以下的罚款；没有违法所得或者违法所得不足五千元的，并处五千元以上二万元以下的罚款；情节严重的，由原认可或者批准机关取消其相应的资格；对直接负责的主管人员和其他直接责任人员，依法给予降级、撤职或者开除的处分；构成犯罪的，依法追究刑事责任:

（一）超出资质认可或者批准范围从事职业卫生技术服务或者职业健康检查、职业病诊断的；

（二）不按照本法规定履行法定职责的；

（三）出具虚假证明文件的。

第八十二条　职业病诊断鉴定委员会组成人员收受职业病诊断争议当事人的财物或者其他好处的，给予警告，没收收受的财物，可以并处三千元以上五万元以下的罚款，取消其担任职业病诊断鉴定委员会组成人员的资格，并从省、自治区、直辖市人民政府卫生行政部门设立的专家库中予以除名。

第八十三条　卫生行政部门、安全生产监督管理部门不按照规定报告职业病和职业病危害事故的，由上一级行政部门责令改正，通报批评，给予警告；虚报、瞒报的，对单位负责人、直接负责的主管人员和其他直接责任人员依法给予降级、撤职或者开除的处分。

第八十四条　违反本法第十七条、第十八条规定，有关部门擅自批准建设项目或者发放施工许可的，对该部门直接负责的主管人员和其他直接责任人员，由监察机关或者上级机关依法给予记过直至开除的处分。

第八十五条　县级以上地方人民政府在职业病防治工作中未依照本法履行职责，本行政区域出现重大职业病危害事故、造成严重社会影响的，依法对直接负责的主管人员和其他直接责任人员给予记大过直至开除的处分。

县级以上人民政府职业卫生监督管理部门不履行本法规定的职责，滥用职权、玩忽职守、徇私舞弊，依法对直接负责的主管人员和其他直接责任人员给予记大过或者降级的处分；造成职业病危害事故或者其他严重后果的，依法给予撤职或者开除的处分。

第八十六条　违反本法规定，构成犯罪的，依法追究刑事责任。

第七章　附则

第八十七条　本法下列用语的含义:

职业病危害，是指对从事职业活动的劳动者可能导致职业病的各种危害。职业病危害因素包括:职业活动中存在的各种有害的化学、物理、生物因素以及在作业过程中产生的其他职业有害因素。

职业禁忌，是指劳动者从事特定职业或者接触特定职业病危害因素时，比一般职业人群更易于遭受职业病危害和罹患职业病或者可能导致原有自身疾病病情加重，或者在从事作业过程中诱发可能导致对他人生命健康构成危险的疾病的个人特殊生理或者病理状态。

第八十八条　本法第二条规定的用人单位以外的单位，产生职业病危害的，其职业病防治活动可以参照本法执行。

劳务派遣用工单位应当履行本法规定的用人单位的义务。

中国人民解放军参照执行本法的办法，由国务院、中央军事委员会制定。

第八十九条　对医疗机构放射性职业病危害控制的监督管理，由卫生行政部门依照本法的规定实施。

第九十条　本法自 2002 年 5 月 1 日起施行。

Law of the People's Republic of China on the Prevention and Control of Occupational Diseases

(Adopted at the 24th session of the Standing Committee of the Ninth National People's Congress on October 27, 2001; and amended according to the Decision on Amending the Law of the People's Republic of China on the Prevention and Control of Occupational Diseases as adopted at the 24th session of the Standing Committee of the Eleventh National People's Congress on December 31, 2011)

Contents

Chapter I General Provisions

Article 1 To prevent, control, and eliminate occupational disease hazards, prevent and control occupational diseases, protect the health and relevant rights and interests of employees, and promote economic and social development, this Law is formulated in accordance with the Constitution.

Article 2 This law shall apply to the prevention and control of occupational diseases within the territory of the People's Republic of China.

For the purposes of this Law, "occupational diseases" means the diseases contracted by the employees of an enterprise, a public institution, an individual economic organization, or other employer for their exposures to toxic or harmful factors such as dust and radioactive substances in occupational activities.

The categories and catalogue of occupational diseases shall be determined, adjusted, and published by the health administrative department of the State Council in conjunction with the work safety administrative department and labor and social security administrative department of

the State Council.

Article 3 In the prevention and control of occupational diseases, the guideline of "focusing on prevention and combining prevention with control" shall be followed, a mechanism of "responsibility of the employers, regulation by the administrative organs, industry self-discipline, participation by the employees, and supervision by the general public" shall be established, and categorized management and comprehensive control shall be implemented.

Article 4 Employees shall be entitled to occupational health protection according to law.

Employers shall create work environment and conditions meeting the national occupational health standards and health requirements and take measures to ensure that employees receive occupational health protection.

Trade unions shall oversee the prevention and control of occupational diseases and protect the lawful rights and interests of employees according to law. When formulating or amending rules and regulations on the prevention and control of occupational diseases, employers shall solicit the opinions of trade unions.

Article 5 Employers shall establish and improve a responsibility system for the prevention and control of occupational diseases, strengthen the management of prevention and control of occupational diseases, improve their capabilities of prevention and control of occupational diseases, and assume responsibilities for their own occupational disease hazards.

Article 6 The primary person in charge of an employer shall assume the overall responsibility for the employer's prevention and control of occupational diseases.

Article 7 Employers must participate in work-related injury insurance according to law.

The labor and social security administrative departments of the State Council and the local people's governments at and above the county level shall strengthen their supervision and administration of work-related injury insurance and ensure that employees enjoy the benefits of work-related injury insurance according to law.

Article 8 The State encourages and supports the research, development, promotion, and application of new technologies, new processes, new equipment, and new materials which facilitate the prevention and control of occupational diseases and the health protection of employees and accentuates the fundamental research on the mechanisms and occurrence patterns of occupational diseases to elevate the scientific and technological levels in the prevention and control of occupational diseases; technologies, processes, equipment, and materials which are effective for the prevention and control of occupational diseases shall be actively adopted; and technologies, processes, equipment, and materials which cause serious occupational disease hazards shall be restricted in use or eliminated.

The State encourages and supports the construction of medical rehabilitation institutions for occupational diseases.

Article 9 The State shall apply an occupational health supervision system.

The work safety administrative department, health administrative department, and labor and social security administrative department of the State Council shall, according to the functions prescribed by this Law and the State Council, supervise and administer the prevention and control of occupational diseases across the country. Other relevant departments of the State Council shall, within their respective functions, supervise and administer the prevention and control of occupational diseases.

The work safety administrative departments, health administrative departments, and labor and social security administrative departments of the local people's governments at and above the county level shall, according to their respective functions, supervise and administer the prevention and control of occupational diseases within their respective administrative regions. Other relevant departments of the local people's governments at and above the county level shall supervise and administer the prevention and control of occupational diseases within their respective functions.

The work safety administrative departments, health administrative departments, and labor and social security administrative departments of the people's governments at and above the county level (hereinafter together referred to as the "departments of occupational health supervision and administration") shall strengthen communication and cooperate closely with each other and, according to their respective functions, legally exercise powers and assume responsibilities.

Article 10 The State Council and the local people's governments at and above the county level shall prepare plans on the prevention and control of occupational diseases, which shall be included in the national economic and social development plan, and organize the implementation of such plans.

The local people's governments at and above the county level shall uniformly lead, organize, and coordinate work on the prevention and control of occupational diseases within their respective administrative regions, establish effective working systems and mechanisms for the prevention and control of occupational diseases, and uniformly lead and direct work in response to occupational health emergencies; and enhance their capabilities of preventing and controlling occupational diseases and related service systems and improve and implement the responsibility system for the prevention and control of occupational diseases.

The people's governments of townships, ethnic townships, and towns shall, in accordance with this Law, support the departments of occupational health supervision and administration in performing their statutory functions.

Article 11 The departments of occupational health supervision and administration of the people's governments at and above the county level shall provide more publicity and education on the

prevention and control of occupational diseases, disseminate knowledge on the prevention and control of occupational diseases, reinforce employers' awareness of prevention and control of occupational diseases, and improve employees' awareness of occupational health and self-protection and ability to exercise rights to occupational health protection.

Article 12 The national occupational health standards on the prevention and control of occupational diseases shall be formulated and published by the health administrative department of the State Council.

The health administrative department of the State Council shall organize monitoring and special investigations on major occupational diseases and assessments on occupational health risks to provide a scientific basis for formulating occupational health standards and policies for the prevention and control of occupational diseases.

The health administrative departments of the local people's governments at and above the county level shall collect statistics and conduct survey and analysis on the prevention and control of occupational diseases within their respective administrative regions on a regular basis.

Article 13 Any entity or individual shall have the right to report and make accusations regarding violations of this Law. The relevant departments shall handle such reports and accusations in a timely manner after receipt.

Entities and individuals which have made remarkable achievements in the prevention and control of occupational diseases shall be rewarded.

Chapter II Early Prevention

Article 14 Employers shall, as required by laws and regulations, strictly comply with the national occupational health standards and implement preventative measures against occupational diseases to control and eliminate occupational disease hazards at source.

Article 15 The formation of an employer with occupational disease hazards shall meet the requirements of laws and administrative regulations, and the employer's work sites shall also meet the following occupational health requirements:

(1) The intensity or density of occupational disease hazard factors meets the national occupational health standards;

(2) There are facilities suitable for protection from occupational disease hazards;

(3) The production layout is reasonable and conforms to the principle of separating harmful operations from harmless operations;

(4) There are accessory health facilities, such as changing rooms, bathrooms, and lounges for

pregnant women;

(5) Equipment, tools, appliances, and other facilities shall meet the requirements for protecting the physical and mental health of employees; and

(6) Other requirements of laws, administrative regulations, and the health administrative department and work safety administrative department of the State Council for protecting the health of employees.

Article 16 The State shall establish a declaration system for projects with occupational disease hazards.

Where an employer's work site has any occupational disease hazard factors as listed in the catalogue of occupational diseases, the employer shall truthfully declare the hazardous project to the local work safety administrative department in a timely manner and accept supervision.

A catalogue of categorized occupational disease hazard factors shall be formulated, adjusted, and published by the health administrative department of the State Council in conjunction with the work safety administrative department of the State Council. The specific measures for declaration of projects with occupational disease hazards shall be formulated by the work safety administrative department of the State Council.

Article 17 Where a new construction, expansion, or reconstruction project or a technical improvement or technology introduction project (hereinafter referred to as the "construction project") may cause any occupational disease hazards, the construction employer shall submit a preliminary evaluation report on occupational disease hazards to the work safety administrative department at the feasibility study stage. The work safety administrative department shall, within 30 days from the date of receipt of the report, make a decision and notify the construction employer of the decision in writing. The relevant departments shall not approve the construction project if no preliminary evaluation report has been submitted or the report hasn't been approved by the work safety administrative department.

In the preliminary evaluation report on occupational disease hazards, the occupational disease hazard factors which may arise from the construction project and their effects on the work sites and the health of employees shall be evaluated, the hazards shall be categorized, and the protective measures against occupational diseases shall be determined.

The measures for the categorized administration of occupational disease hazards in construction projects shall be formulated by the work safety administrative department of the State Council.

Article 18 The expenses necessary for the protective facilities against occupational diseases of a construction project shall be included in the project budget of the construction project, and such facilities shall be designed, constructed, and put to use in production and other operations at the same time as the main body of the project.

For a construction project with serious occupational disease hazards, the design of protective facilities shall be examined by the work safety administrative department, and construction may commence only after the national occupational health standards and health requirements are met.

Before the as-built acceptance check of a construction project, the construction employer shall evaluate the effects of occupational disease hazard control. The protective facilities against occupational diseases may be put to use in regular production and other operations only after passing the as-built acceptance check conducted by the work safety administrative department.

Article 19 The preliminary evaluation of occupational disease hazards and the evaluation of effects of occupational disease hazard control shall be conducted by the legally established occupational health technical service institutions accredited by the work safety administrative department of the State Council or the work safety administrative department of the local people's government at or above the level of a districted city according to its functions. The occupational health technical service institutions shall provide objective and authentic evaluations.

Article 20 The State shall apply special administration to radioactive, highly toxic, and high-risk dust operations. The specific administrative measures shall be formulated by the State Council.

Chapter III Protection and Management during Employment

Article 21 An employer shall take the following management measures for the prevention and control of occupational diseases:

(1) forming or designating an occupational health management body or organization and having full-time or part-time occupational health management personnel to be responsible for the employer's prevention and control of occupational diseases;

(2) preparing plans and implementation schemes for the prevention and control of occupational diseases;

(3) establishing and improving occupational health management rules and operating procedures;

(4) establishing and improving occupational health archives and employee health surveillance archives;

(5) establishing and improving the rules for monitoring and evaluating occupational disease hazard factors at work sites; and

(6) establishing and improving the emergency response plans for occupational disease hazard accidents.

Article 22 Employers shall ensure the funds required for the prevention and control of occupational diseases, shall not divert or misappropriate such funds, and shall be liable for the

consequences of insufficient funds.

Article 23 Employers must adopt effective protective facilities against occupational diseases and provide employees with occupational disease protection items for personal use.

The occupational disease protection items for personal use provided by an employer to its employees must meet the requirements for the prevention and control of occupational diseases; and those failing to meet such requirements shall not be used.

Article 24 Employers shall adopt preferably new technologies, new processes, new equipment, and new materials which facilitate the prevention and control of occupational diseases and the protection of health of employees and gradually replace technologies, processes, equipment, and materials causing serious occupational disease hazards.

Article 25 An employer with occupational disease hazards shall set up a bulletin board in a conspicuous position to disclose its rules, regulations and operating procedures related to the prevention and control of occupational diseases, emergency rescue measures in response to occupational disease hazard accidents, and testing results of occupational disease hazard factors at work sites.

For work posts with serious occupational disease hazards, an employer shall set warning signs and Chinese warning explanations in a conspicuous place. The warning explanations shall indicate the categories, consequences, and prevention of occupational disease hazards, the emergency rescue and treatment measures, and so on.

Article 26 For toxic or harmful work sites where acute occupational injuries may occur, an employer shall install alarms and provide on-spot rescue items, washing equipment, emergency evacuation exits, and necessary hazard buffer zones.

For radioactive work sites and the transport and storage of radioactive isotopes, an employer must provide protective equipment, install alarms, and ensure that its personnel exposed to radiation carry a personal dosage gauge.

For the protective equipment against occupational diseases, emergency rescue facilities, and occupational disease protection items for personal use, an employer shall conduct routine maintenance and repair, and regularly test their performances and effects, to ensure that they are in normal condition; and shall not dismantle or discontinue the use of them without permission.

Article 27 Employers shall designate special persons responsible for the daily monitoring of occupational disease hazard factors and ensure the normal operation of the monitoring system.

An employer shall, according to the provisions of the work safety administrative department of the State Council, conduct regular tests and evaluations of the occupational disease hazard factors at its work sites. The results of such tests and evaluations shall be entered into the occupational

health archives of the employer and, on a regular basis, be reported to the local work safety administrative department and disclosed to its employees.

The tests and evaluations of occupational disease hazard factors shall be conducted by the legally established occupational health technical service institutions accredited by the work safety administrative department of the State Council or the work safety administrative department of the local people's government at or above level of a districted city according to its functions. The occupational health technical service institutions shall provide objective and authentic tests and evaluations.

When discovering that the occupational disease hazard factors at a work site fail to meet the national occupational health standards and health requirements, an employer shall take corresponding control measures immediately, and if the national occupational health standards and health requirements are still not met, the employer must discontinue operations with occupational disease hazard factors; and such operations may be resumed only after the occupational disease hazard factors have met the national occupational health standards and health requirements after control measures are taken.

Article 28 Occupational health technical service institutions shall legally conduct tests and evaluations of occupational disease hazard factors and accept supervision and inspection by the work safety administrative departments. Work safety administrative departments shall legally perform their duties of supervision.

Article 29 To supply an employer with equipment which may cause any occupational disease hazards, a supplier shall provide Chinese instructions and set warning signs and Chinese warning explanations in a conspicuous place of such equipment. The warning explanations shall include the performances of equipment, possible occupational disease hazards, important matters on safe operation and maintenance, protection against occupational diseases, measures for emergency rescue and treatment, and so on.

Article 30 To supply an employer with chemicals, radioactive isotopes, or materials containing radioactive substances which may cause occupational disease hazards, a supplier shall provide Chinese instructions. The instructions shall include the characteristics of products, main ingredients, existing harmful factors, possible harmful consequences, important matters on safe operation, protection against occupational diseases, emergency rescue and treatment measures, and so on. There shall be conspicuous warning signs and Chinese warning explanations on product packages. Dangerous item signs or radiation warning signs shall be set in the prescribed places of storages for the above materials.

For any chemical material related to occupational disease hazards which is used in China or imported into China for the first time, the entity using or importing the chemical material shall, after obtaining the approval of the relevant department of the State Council according to the State provisions, submit the toxicity identification report on the chemical material, documents on registration or approval of import issued by the relevant departments, and other information to the

health administrative department and work safety administrative department of the State Council.

Radioactive isotopes, radial equipment, and items containing radioactive substances shall be imported according to the relevant State provisions.

Article 31 No entity or individual may produce, deal in, import, or use any equipment or material which may cause occupational disease hazards and whose use is expressly prohibited by the State.

Article 32 No entity or individual may transfer operations causing occupational disease hazards to any entity or individual which does not meet the conditions for protection from occupational diseases. No entity or individual which does not meet the conditions for protection from occupational diseases may accept operations causing occupational disease hazards.

Article 33 Where an employer which shall know the occupational disease hazards caused by the adopted technologies, processes, equipment, and materials adopts any technology, process, equipment, or material causing occupational disease hazards by concealing such hazards, the employer shall be liable for the consequences of such hazards.

Article 34 When signing labor contracts (including employment contracts for public services) with its employees, an employer shall truthfully inform its employees of the occupational disease hazards which may arise in the work process, the consequences thereof, the protective measures against occupational diseases, remuneration, and other matters and include the same in the labor contracts; and shall not conceal such information or defraud its employees.

Where any employee conducts operations causing occupational disease hazards not included in the labor contract signed for any change of position or specific work during the contract period, the employer shall perform its obligation to truthfully inform the employee of such hazards as described in the preceding paragraph and modify the relevant clauses of the original labor contract.

Where the employer violates the provisions of either of the preceding two paragraphs, the employee shall be entitled to refuse to conduct operations causing occupational disease hazards, and the employer shall not therefore rescind the labor contract signed with the employee.

Article 35 The primary person in charge and the occupational health management personnel of an employer shall receive occupational health training, abide by laws and regulations on the prevention and control of occupational diseases, and organize the employer’s prevention and control of occupational diseases according to law.

Employers shall provide pre-job occupational health training and regular on-the-job occupational health training for employees, disseminate occupational health knowledge, supervise employees in abiding by laws, regulations, rules, and operating procedures on the prevention and control of occupational diseases, and direct employees to correctly use occupational disease protective equipment and occupational disease protective items for personal use.

Employees shall gain occupational health knowledge through studies, enhance their awareness of preventing occupational diseases, abide by laws, regulations, rules, and operating procedures on the prevention and control of occupational diseases, properly use and maintain occupational disease protective equipment and occupational disease protective items for personal use, and report any discovered risks of occupational disease hazard accidents in a timely manner.

Employers shall educate employees who don't perform the obligations in the preceding paragraph.

Article 36 For employees conducting operations with exposure to occupational disease hazards, an employer shall organize pre-job, on-the-job, and off-the-job occupational health examination of employees according to the provisions of the work safety administrative department and health administrative department of the State Council and inform in writing employees of the examination results. The expenses for the occupational health examination shall be assumed by the employer.

Employers shall not assign employees who have not undergone the pre-job occupational health examination to operations with exposure to occupational disease hazards; shall not assign employees with occupational contraindications to operations causing such contraindications; shall transfer employees who are found during occupational health examination to have suffered health injuries related to their jobs from such jobs and settle such employees appropriately; and shall not rescind or terminate labor contacts with employees who have not undergone the off-the-job occupational health examination.

The occupational health examination shall be conducted by medical health institutions approved by the health administrative departments of the people's governments at and above the provincial level.

Article 37 Employers shall establish occupational health surveillance archives for employees and appropriately maintain the archives for a prescribed period.

The occupational health surveillance archives shall include the occupational history, history of exposures to occupational disease hazards, occupational health examination results, diagnosis and treatment of occupational diseases, and other relevant personal health information on employees.

Employees leaving an employer shall be entitled to request a copy of their own occupational health surveillance files, and the employer shall provide a true copy of such files free of charge and sign and seal the copy provided.

Article 38 Where an acute occupational disease hazard accident occurs or may occur, an employer shall immediately take emergency rescue and control measures and report the accident to the local work safety administrative department and relevant departments in a timely manner. The work safety administrative department shall, after receiving the report, organize investigation and disposition in a timely manner in conjunction with the relevant departments; and when necessary, may take temporary control measures. The health administrative department shall organize

effective medical treatment.

For employees who suffer or may suffer any acute occupational disease hazard, an employer shall organize rescue and treatment and conduct health examination and medical observation in a timely manner, and the necessary expenses shall be assumed by the employer.

Article 39 Employers shall not assign underage employees to operations with exposure to occupational disease hazards; and shall not assign female employees in pregnancy or lactation to operations causing hazards to them and their fetuses or babies.

Article 40 Employees shall enjoy the following rights in occupational health protection:

(1) receive occupational health education and training;

(2) receive occupational health examination, occupational disease diagnosis, treatment, and rehabilitation, and other services for the prevention and control of occupational diseases;

(3) be informed of the occupational disease hazard factors which arise or may arise at the work site, the consequences of such hazards, and the protective measures to be taken for the prevention and control of occupational diseases;

(4) request an employer to provide occupational disease protective facilities and occupational disease protective items for personal use satisfying the requirements for the prevention and control of occupational diseases and improve working conditions;

(5) criticize or file reports or accusations on conduct which violates laws and regulations on the prevention and control of occupational diseases or endangers life or health;

(6) refuse to follow directions contrary to rules and procedures or conduct forced operations in the absence of occupational disease protective measures; and

(7) participate in the democratic management of occupational health of the employer and offer opinions and suggestions on the prevention and control of occupational diseases. Employers shall guarantee that employees are able to exercise the rights as described in the preceding paragraph.

Where an employer reduces the salary, welfare, or other remuneration of an employee or rescinds or terminates the labor contract signed with an employee because the employee has exercised his or her lawful rights according to law, such conduct of the employer shall be void.

Article 41 The trade union of an employer shall oversee and assist the employer in providing publicity, education and training regarding occupational health, be entitled to offer opinions and suggestions on the employer’s prevention and control of occupational diseases, legally conclude a special collective contract on labor safety and health with the employer on behalf of employees, consult with the employer over issues raised by employees concerning the prevention and control

of occupational diseases, and promote the resolution of such issues.

The trade union of an employer shall be entitled to require correction of the employer's conduct which violates laws and regulations on the prevention and control of occupational diseases and infringes upon the lawful rights and interests of employees; be entitled to require the employer to take protective measures or offer suggestions to the relevant government departments regarding the adoption of compulsory measures, when any serious occupational disease hazard arises; be entitled to participate in accident investigation and disposition, when any occupational disease hazard accident occurs; and be entitled to offer suggestions to the employer regarding evacuation of employees from a dangerous site when discovering any circumstances which endanger the life or health of employees, and the employer shall handle such suggestions immediately.

Article 42 The expenses incurred by an employer in the prevention and control of occupational disease hazards, health testing of work sites, health surveillance, occupational health training, and so on as required for the prevention and control of occupational diseases shall be truthfully recorded under production costs according to the relevant provisions of the State.

Article 43 The departments of occupational health supervision and administration shall, according to their respective functions, strengthen their supervision and inspection on employers' adoption of management measures for protection from occupational diseases and legally exercise powers and assume responsibilities.

Chapter IV Occupational Disease Diagnosis and Safeguards for Occupational Disease Patients

Article 44 Medical and health institutions shall provide occupational disease diagnosis with the approval of the health administrative department of the people's government of a province, autonomous region, or municipality directly under the Central Government. The health administrative department of the people's government of a province, autonomous region, or municipality directly under the Central Government shall publish a list of medical and health institutions providing occupational disease diagnosis within its administrative region.

Medical and health institutions providing occupational disease diagnosis shall meet the following conditions:

(1) hold a Practicing License for a Medical Institution;

(2) have medical and health technical personnel appropriate for providing occupational disease diagnosis;

(3) have instruments and equipment appropriate for providing occupational disease diagnosis; and

(4) have effective quality management rules for occupational disease diagnosis.

No medical and health institutions providing occupational disease diagnosis shall refuse an

employee's request for occupational disease diagnosis.

Article 45 An employee may seek occupational disease diagnosis at a medical and health institution legally providing occupational disease diagnosis at the place where the employer is located, at the place of the employee's registered permanent residence, or at the place of the employee's habitual residence.

Article 46 The diagnosis standards for occupational diseases and the diagnosis and identification measures for occupational diseases shall be formulated by the health administrative department of the State Council. The disability grade identification measures for occupational diseases shall be formulated by the labor and social security administrative department of the State Council in conjunction with the health administrative department of the State Council.

Article 47 In occupational disease diagnosis, a comprehensive analysis of the following factors shall be conducted:

(1) the occupational history of a patient;

(2) a history of exposures to occupational disease hazards and information on occupational disease hazard factors in the work site; and

(3) clinical manifestations, results of assistant examination, and so on.

Where there is no evidence for denying a necessary connection between occupational disease hazard factors and a patient's clinical manifestations, the patient shall be diagnosed with an occupational disease.

A medical institution providing occupational disease diagnosis shall, when conducting occupational disease diagnosis, organize three or more licensed doctors who are qualified for occupational disease diagnosis to conduct a group diagnosis.

The certification of occupational disease diagnosis shall be jointly signed by the doctors participating in the diagnosis, to which the seal of the medical institution providing the occupational disease diagnosis shall be affixed upon verification.

Article 48 An employer shall truthfully provide the occupational history and history of exposures to occupational disease hazard factors of employees, test results of occupational disease hazard factors at work sites, and other information necessary for occupational disease diagnosis or identification; the work safety administrative department shall oversee and urge the employer to provide the aforesaid information; and employees and relevant institutions shall also provide information related to occupational disease diagnosis or identification.

Where an occupational disease diagnosis or identification institution needs information on the occupational disease hazard factors at a work site, it may conduct an on-site investigation of the

work site or request the work safety administrative department to do so, and the work safety administrative department shall organize an on-site investigation within 10 days. The employer shall not refuse or obstruct the on-site investigation.

Article 49 Where, in the process of occupational disease diagnosis or identification, an employer fails to provide the test results of occupational disease hazard factors at a work site and other information, the diagnosis or identification institution shall, in consideration of the clinical manifestations and assistant examination results of an employee, the occupational history and history of exposures to occupational disease hazards of an employee, the personal Statement of an employee, the routine supervision and inspection information from the work safety administrative department, and other information, arrive at a conclusion of occupational disease diagnosis or identification.

Where an employee raises any objection to the test results of occupational disease hazard factors at a work site and other information provided by the employer or the aforesaid information is not provided because of the dissolution or bankruptcy of the employer, the diagnosis or identification institution shall request the work safety administrative department to conduct an investigation, and the work safety administrative department shall, within 30 days after receiving the request, make a determination on the information in dispute or information on occupational disease hazard factors at the work site; and the relevant departments shall cooperate.

Article 50 Where, in the process of occupational disease diagnosis or identification, the parties dispute the employment relationship, type of work, post, or working hours when the employee's occupational history and history of exposures to occupational disease hazard factors are validated, they may apply to the local labor and personnel dispute arbitration committee for arbitration; and the labor and personnel dispute arbitration committee receiving the application shall accept it and render an award within 30 days.

The parties shall provide evidence for their own claims during arbitration. Where an employee cannot provide evidence relevant to his or her arbitral claims that is controlled or managed by the employer, the arbitral tribunal shall require the employer to provide such evidence within a specified time limit; and the employer shall assume any adverse consequences for failing to provide such evidence within the specified time limit.

An employee may file a lawsuit with the people's court against an arbitral award.

An employer may, within 15 days after the end of the occupational disease diagnosis or identification procedure, file a lawsuit with the people's court according to law against an arbitral award. During the lawsuit, the treatment expenses of the employee shall be paid from financial sources prescribed for occupational diseases.

Article 51 Employers and medical and health institutions shall report in a timely manner discovered occupational disease patients or patients suspected of occupational diseases to the local health administrative department and work safety administrative department. If an occupational

disease is confirmed, an employer shall also report to the local labor and social security administrative department. The departments receiving such reports shall make dispositions according to law.

Article 52 The health administrative departments of the local people's governments at and above the county level shall administer the statistical reports on occupational diseases within their respective administrative regions and report to the higher authorities according to the relevant provisions.

Article 53 A party raising any objection to the occupational disease diagnosis may apply for identification to the health administrative department of the people's government of the place where the medical or health institution making the diagnosis is located.

In case of disputes over occupational disease diagnosis, the health administrative department of the local people's government at or above the level of a districted city shall, upon the application of a party, organize identification by the occupational disease diagnosis identification committee.

A party disagreeing to the identification conclusion of the occupational disease diagnosis identification committee at the level of a districted city may apply for re-identification to the health administrative department of the people's government of a province, autonomous region, or municipality directly under the Central Government.

Article 54 The occupational disease diagnosis identification committee shall be composed of experts in relevant areas.

The health administrative department of the people's government of a province, autonomous region, or municipalities directly under the Central Government shall create relevant expert databases, and when it is necessary to conduct diagnosis identification for occupational disease disputes, the parties or the relevant health administrative department authorized by the parties shall determine the experts sitting on the diagnosis identification committee in the method of random selection from expert databases.

The occupational disease diagnosis identification committee shall conduct occupational disease diagnosis identification according to the diagnosis standards for occupational diseases and the diagnosis and identification measures for occupational diseases issued by the health administrative department of the State Council and issue a certificate of occupational disease diagnosis identification to the parties. The occupational disease diagnosis and identification expenses shall be assumed by employers.

Article 55 The members of an occupational disease diagnosis identification committee shall abide by professional ethics, conduct diagnosis identification objectively and impartially, and assume corresponding responsibilities. The members of an occupational disease diagnosis appraisal committee shall not contact the parties in private, shall not accept any property or other benefits from the parties, and shall be disqualified if having any interest relationship with the parties.

Where the relevant cases accepted by a people's court need occupational disease identification, the people's court shall select the experts participating in the identification from the relevant expert databases legally created by the health administrative departments of the people's governments of a province, autonomous region, or municipalities directly under the Central Government.

Article 56 Medical and health institutions shall, after discovering patients suspected of occupational diseases, shall inform the employees themselves and notify the employers in a timely manner.

Employers shall arrange in a timely manner the diagnosis of patients suspected of occupational diseases; and shall not rescind or terminate the labor contracts with such patients during their diagnosis or medical observation period.

The expenses incurred by patients suspected of occupational diseases during the diagnosis or medical observation period shall be assumed by employers.

Article 57 Employers shall ensure that occupational diseases patients enjoy the occupational disease benefits prescribed by the State.

Employers shall, according to the relevant provisions of the State, arrange the diagnosis, rehabilitation, and regular examination of occupational diseases patients.

Employers shall transfer occupational disease patients who are no longer suitable for their original jobs from their jobs and settle them appropriately.

Employers shall provide appropriate job allowances to employees conducting operations with exposure to occupational disease hazards.

Article 58 The expenses for the diagnosis and rehabilitation of occupational disease patients and the social security of occupational disease patients who are disabled or have lost work ability shall be governed by the State provisions on work-related injury insurance.

Article 59 In addition to enjoying the benefits of work-related injury insurance according to law, an occupational disease patient who is entitled to compensation according to relevant civil laws shall have the right to request compensation from the employer.

Article 60 Where an employee is diagnosed with an occupational disease but the employer fails to participate in the work-related injury insurance as required by law, the employee's medical and living expenses shall be assumed by the employer.

Article 61 The benefits enjoyed by occupational diseases patients shall remain unchanged when they change their employers.

An employer undergoing any business split or combination, dissolution, or bankruptcy shall

provide health examination for employees conducting operations with exposure to occupational disease hazards and appropriately settle occupational diseases patients according to the relevant provisions of the State.

Article 62 Where the employer of an occupational disease patient no longer exists or the employment relationship of an occupational disease cannot be confirmed, the patient may apply to the civil affairs department of the local people's government for medical assistance, subsistence support, and so on.

The local people's governments at all levels shall, based on the actual local circumstances, take other measures to secure medical assistance and treatment for occupational disease patients in the preceding paragraph.

Chapter V Supervision and Inspection

Article 63 The departments of occupational health supervision and administration of the people's governments at and above the county level shall, in accordance with laws and regulations on the prevention and control of occupational diseases and national occupational health standards and health requirements, conduct supervision and inspection on the prevention and control of occupational diseases according to their respective functions.

Article 64 The work safety administrative departments shall have the right to take the following measures when performing their functions of supervision and inspection:

(1) entering an entity under inspection and a site with occupational disease hazards to learn relevant information, conduct investigation, and gather evidence;

(2) consulting or copying materials related to acts which violate laws and regulations on the prevention and control of occupational diseases and collecting samples; and

(3) ordering entities and individuals which violate laws and regulations on the prevention and control of occupational diseases to cease violations.

Article 65 Where an occupational disease hazard accident occurs or there is evidence that the State of hazards may cause the occurrence of an occupational disease hazard accident, the work safety administrative department may take the following temporary control measures:

(1) ordering suspension of operations which have caused an occupational disease hazard accident;

(2) sealing up materials and equipment which have caused an occupational disease hazard accident or may cause the occurrence of an occupational disease hazard accident; and

(3) organizing control over the site of an occupational disease hazard accident.

After an occupational disease hazard accident or the hazardous State is effectively controlled, the work safety administrative department shall remove the control measures in a timely manner.

Article 66 The law enforcement personnel of occupational health supervision shall produce their law enforcement credentials when performing their duties.

The law enforcement personnel of occupational health supervision shall be devoted to their duties, be impartial in law enforcement, and strictly abide by law enforcement rules; and keep confidential the involved secrets of employers.

Article 67 When the law enforcement personnel of occupational health supervision perform their duties according to law, the entities under inspection shall accept inspection and provide support and assistance, and shall not refuse or obstruct inspection.

Article 68 When performing their functions, the work safety administrative departments and their law enforcement personnel of occupational health supervision shall not:

(1) grant relevant certification documents for a construction project, qualification certification documents, or approval, when the statutory conditions are not met;

(2) fail to perform the functions of supervision and inspection on those that have obtained the relevant certification documents;

(3) fail to take control measures in a timely manner according to law after discovering that an employer has occupational disease hazards which may cause an occupational disease hazard accident; and

(4) otherwise violate this Law.

Article 69 The law enforcement personnel of occupational health supervision shall undergo qualification procedures according to law.

The departments of occupational health supervision and administration shall strengthen their team building, improve the political awareness and professional capabilities of their law enforcement personnel of occupational health supervision, and establish and improve an internal supervision system in accordance with this Law and other relevant laws and regulations to oversee their personnel's enforcement of laws and regulations and compliance with disciplines.

Chapter VI Legal Liability

Article 70 Where a construction employer has committed any of the following conduct in violation of the provisions of this Law, the work safety administrative department shall issue a warning to it and order it to make correction within a prescribed time limit; impose a fine of not less than CNY 100,000 but not more than CNY 500,000 on it if no correction is made within the

time limit; and for serious circumstances, order it to cease operations causing occupational disease hazards or request the relevant people's government to order cessation of construction or a shutdown according to the powers granted by the State Council:

(1) commencing construction without conducting a preliminary assessment of occupational disease hazards as required, without submitting a report on the preliminary assessment of occupational disease hazards, or without obtaining an approval from the work safety administrative department of the report on the preliminary assessment of occupational disease hazards;

(2) failing to put to use the occupational disease protective facilities of a construction project for production and other business operations at the same time as the main body of the project;

(3) commencing construction of a construction project with serious occupational disease hazards whose design for occupational disease protective facilities has not been examined by the work safety administrative department or fails to meet the national occupational health standards and health requirements; or

(4) putting to use the occupational disease protective facilities without conducting an evaluation of the control effects of occupational disease hazards according to the relevant provisions or without undergoing or passing the acceptance check conducted by the work safety administrative department.

Article 71 Whoever has committed any of the following conduct in violation of the provisions of this Law shall be warned and ordered to make correction by the work safety administrative department; and, if no correction is made within the time limit, be fined not more than CNY 100,000:

(1) failing to archive, report to the higher authorities, or publish the results of testing or evaluation of occupational disease hazards at work sites;

(2) failing to take the management measures for the prevention and control of occupational diseases as set forth in Article 21 of this Law;

(3) failing to publish the rules, regulations, and operating procedures for the prevention and control of occupational diseases and the emergency rescue measures for occupational disease hazard accidents according to the relevant provisions;

(4) failing to organize employees to receive occupational health training according to the relevant provisions or failing to adopt directive and supervisory measures for employees' self-protection against occupational diseases; or

(5) failing to submit a toxicity identification report and documents on registration or approval of import issued by the relevant departments according to the relevant provisions, for any chemical

material related to occupational disease hazards which is used in China or imported into China for the first time.

Article 72 Where an employer has committed any of the following conduct in violation of the provisions of this Law, the work safety administrative department shall order it to make correction within a prescribed time limit and issue a warning to it and may also impose a fine of not less than CNY 50,000 but not more than CNY 100,000 on it:

(1) failing to truthfully report projects with occupational disease hazards to the work safety administrative department in a timely manner according to the relevant provisions;

(2) failing to assign special persons to be responsible for the routine monitoring of occupational disease hazard factors or having a monitor system which fails to monitor normally;

(3) failing to inform employees of true conditions of occupational disease hazards when signing or modifying labor contracts;

(4) failing to organize occupational health examination or establish occupational health surveillance archives according to the relevant provisions or failing to inform in writing employees of the examination results; or

(5) failing to provide a copy of occupational health surveillance files according to the provisions of this Law when employees leave the employer.

Article 73 Where an employer has committed any of the following conduct in violation of the provisions of this Law, the work safety administrative department shall issue a warning to it and order it to make correction within a prescribed time limit; if no correction is made within the time limit, impose a fine of not less than CNY 50,000 but not more than CNY 200,000 shall be imposed on it; and, for serious circumstances, order it to cease operations causing occupational disease hazards or request the relevant people's government to order a shutdown according to the powers granted by the State Council:

(1) having a work site with the intensity or density of any occupational disease hazard factor exceeding the national occupational health standards;

(2) failing to provide occupational disease protective facilities and occupational disease protective items for personal use or providing occupational disease protective facilities and occupational disease protective items for personal use which do not meet the national occupational health standards and health requirements;

(3) failing to maintain, repair, and test the occupational disease protective equipment, emergent rescue facilities, and occupational disease protective items for personal use according to the relevant provisions or failing to maintain the normal State of operation or use thereof;

(4) failing to test or evaluate the occupational disease hazard factors at a work site according to the relevant provisions;

(5) failing to cease operations with occupational disease hazard factors at a work site, when such factors fail to meet the national occupational health standards and health requirements even after control measures are taken;

(6) failing to arrange the diagnosis and treatment for occupational disease patients and patients suspected of occupational diseases according to the relevant provisions;

(7) failing to immediately take emergency rescue and control measures or failing to report in a timely manner according to the relevant provisions, when an acute occupational disease hazard accident occurs or may occur;

(8) failing to set warning signs and Chinese warning explanations in a conspicuous position of work posts causing serious occupational disease hazards according to the relevant provisions;

(9) refusing supervision and inspection by the departments of occupational health supervision and administration;

(10) withholding, forging, tempering with, or damaging occupational health surveillance files, test and evaluation results of occupational disease hazard factors at a work site, and other relevant information or refusing to provide information necessary for occupational disease diagnosis or identification; or

(11) failing to assume the occupational disease diagnosis or identification expenses and the medical and living security expenses of occupational disease patients according to the relevant provisions.

Article 74 Whoever supplies an employer with equipment or materials which may cause occupational disease hazards without providing Chinese instructions or setting warning marks and Chinese warning explanations according to the relevant provisions shall be ordered to make correction within a prescribed time limit, warned, and fined not less than CNY 50,000 but not more than CNY 200,000 by the work safety administrative department.

Article 75 Where an employer or a medical or health institution fails to report occupational diseases or suspicion of occupational diseases according to the relevant provisions, the relevant competent administrative department shall, according to its functions, order it to make correction within a prescribed time limit and issue a warning to it and may impose a fine of not more than CNY 10,000; if falsification is committed, shall impose a fine of not less than CNY 20,000 but not more than CNY 50,000 on it; and may take the disciplinary action of demotion or removal from office against the directly responsible chief and other directly liable persons according to law.

Article 76 Whoever falls under any of the following circumstances in violation of the provisions

of this Law shall be ordered to implement control measures within a prescribed time limit and fined not less than CNY 50,000 but not more than CNY 300,000 by the work safety administrative department; and, for serious circumstances, the work safety administrative department shall order cessation of operations causing occupational disease hazard or request the relevant people's government to order a shutdown according to the powers granted by the State Council:

(1) adopting any technology, process, equipment, or material by withholding the occupational disease hazards caused by it;

(2) withholding its true occupational health conditions;

(3) failing to comply with the provisions of Article 26 of this Law regarding a toxic or harmful work site or a radioactive work site where acute occupational injuries may occur or the transportation or storage of radioactive isotopes;

(4) using any equipment or material which may cause occupational disease hazards and whose use is expressly prohibited by the State;

(5) transferring operations causing occupational disease hazards to any entity or individual which does not meet the conditions for protection from occupational diseases or accepting operations causing occupational disease hazards if the acceptor is an entity or individual which does not meet the conditions for protection from occupational diseases;

(6) dismantling or discontinuing the use of occupational disease protective equipment or emergency rescue facilities without permission;

(7) assigning employees who have not undergone the occupational health examination, employees who have occupational contraindications, underage employees, or female employees in pregnancy or lactation to operations with exposure to occupational disease hazards or operations with contraindication; or

(8) directing, contrary to rules and procedures, or forcing employees to conduct operations in the absence of occupational disease protective measures.

Article 77 Whoever produces, deals in, or imports any equipment or material which may cause occupational disease hazards and whose use is expressly prohibited by the State shall be punished according to the relevant laws and administrative regulations.

Article 78 Where an employer's violation of this Law has caused any serious damage to the life or health of employees, the work safety administrative department shall order it to cease the operations causing occupational disease hazards or request the relevant people's government to order a shutdown according to the powers granted by the State Council and impose a fine of not less than CNY 100,000 but not more than CNY 500,000 on it.

Article 79 Where an employer's violation of this Law has caused a serious occupational disease hazard accident or any other serious consequences, constituting a crime, the directly responsible chief and other directly liable persons shall be subject to criminal liability according to law.

Article 80 Where any institution not accredited to provide occupational health technical services provides occupational health technical services or a medical or health institution conducts occupational health examination or occupational disease diagnosis without approval, the work safety administrative department and health administrative department shall, according to their respective functions, order it to immediately cease violations of law and confiscate its illegal income; if the illegal income is not less than CNY 5,000, impose a fine of not less than two times but not more than ten times the illegal income on it or, if there is no illegal income or the illegal income is less than CNY 5,000, impose a fine of not less than CNY 5,000 but not more than CNY 50,000 on it; and for serious circumstances, take the disciplinary action of demotion, removal from office, or expulsion according to law against the directly liable person in charge and other directly liable persons.

Article 81 Where an institution providing occupational health technical services or a medical or health institution providing occupational health examination or occupational disease diagnosis has committed any of the following conduct in violation of the provisions of this Law, the work safety administrative department and health administrative department shall, according to their respective functions, order it to immediately cease violations of law, issue a warning to it, and confiscate its illegal income; and if the illegal income is not less than CNY 5,000, impose a fine of not less than two times but not more than five times the illegal income on it or, if there is no illegal income or the illegal income is less than CNY 5,000, impose a fine of not less than CNY 5,000 but not more than CNY 20,000 on it; for serious circumstances, the original accreditation or approving organ shall revoke the corresponding qualification of it; the directly responsible chief and other directly liable persons shall be subject to the disciplinary action of demotion, removal from office, or expulsion according to law; and the criminal liability shall be investigated if a crime is constituted:

(1) providing occupational health technical services or occupational health examination or occupational disease diagnosis beyond the scope of accreditation or approval;

(2) failing to perform its statutory duties according to the provisions of this Law; and

(3) issuing false certification documents.

Article 82 Where a member of the occupational disease diagnosis identification committee accepts any property or other benefits from the parties to disputes over occupational disease diagnosis, the member shall be warned and the property accepted shall be confiscated; the member may be fined not less than CNY 3,000 but not more than CNY 5,000; and the member shall be disqualified as a member of the occupational disease diagnosis identification committee and removed from the expert database of the health administrative department of the people's government of a province, autonomous region, or municipality directly under the Central Government.

Article 83 Where a health administrative department or a work safety administrative department fails to report any occupational disease or occupational disease hazard accident as required, the administrative department at the next higher level shall order it to make correction, circulate a notice of criticism, and issue a warning to it; and if the department falsifies a report or withholds information in a report, the person in charge, the directly responsible chief, and other directly liable persons of the department shall be subject to the disciplinary action of demotion, removal from office, or expulsion according to law

Article 84 Where a relevant department approves a construction project or issues a construction license in violation of Article 17 or 18 of this Law, the supervisory authority or the superior authority shall, according to law, take disciplinary actions against the directly responsible chief and other directly liable persons of the department from demerit to expulsion.

Article 85 Where a local people's government at or above the county level fails to perform its functions in accordance with this Law in the prevention and control of occupational diseases, causing the occurrence of a major occupational disease hazard accident in its administrative region with any serious social impact, the directly responsible chief and other directly liable persons shall be subject to disciplinary actions from major demerit to expulsion according to law.

Where a department of occupational health supervision and administration of a people's government at or above the county level fails to perform its functions prescribed by this Law, abuses its powers, neglects its duties, makes falsification, or practices favoritism, the directly responsible chief and other directly liable persons shall be subject to the disciplinary action of major demerit or demotion according to law and, if any occupational disease hazard accident or other serious consequence is caused, shall be subject to the disciplinary action of removal from office or expulsion according to law.

Article 86 Whoever commits a crime by violating this Law shall be subject to criminal liability according to law.

Chapter VII Supplementary Provisions

Article 87 For the purposes of this Law:

"Occupational disease hazards" means various hazards which may cause occupational diseases to employees in occupational activities. "Occupational disease hazard factors" includes: various harmful chemical, physical, and biological factors existing in occupational activities as well as other occupational harmful factors arising in the process of operations.

"Occupational contraindications" means the special individual physiological or pathological State of an employee who is more likely to suffer occupational disease hazards and contract occupational diseases, suffer aggravation of an existing disease, or contract a disease that may endanger the life or health of others during operations than the general working population when the employee is engaged in a particular occupation or exposed to particular occupational disease

hazard factors.

Article 88 The prevention and control of occupational diseases for occupational disease hazards arising in entities other than the employers as set forth in Article 2 of this Law may be implemented by reference to this Law.

Entities using dispatched labor forces shall perform the obligations of employers as prescribed by this Law.

The measures of the People's Liberation Army of China for implementation by reference to this Law shall be formulated by the State Council and the Central Military Committee.

Article 89 The supervision and administration of medical institutions' control of radioactive occupational disease hazards shall be conducted by the health administrative departments in accordance with this Law.

Article 90 This Law shall come into force on May 1, 2002.

TALAT Lecture 1501

Aluminium:
Physical Properties, Characteristics and Alloys

60 pages, 44 figures

Basic Level

prepared by Ron Cobden, Alcan, Banbury

Objectives:

- to provide a survey of the aluminium alloys available to the user
- to describe their various properties
- to give an insight into the choice of aluminium for a proposed application.

In the context of this lecture not every individual alloy and its properties have been treated in detail, but rather divided into alloy types with reference to the most commonly used alloys. For further details on alloy properties the reader is referred to available databanks like ALUSELECT of the European Aluminium Association (EAA) or to the European and national materials standards.

Prerequisites:

- good engineering background in materials, design and manufacturing processes

Date of Issue: 1994

1501 Aluminium: Physical Properties, Characteristics and Alloys

Contents

1501.01 History and Present State of Aluminium Production

- The history and production process of aluminium
- The aluminium industry today
- Recycled or secondary aluminium

The History and Production Process of Aluminium

Rare and expensive a century ago, aluminium has since been identified as the most common metal on earth, forming about eight percent of the earth's crust. It is the third most plentiful element known to man. Only oxygen and silicon (sand) exist in greater quantities.

It was only in 1808 that Sir Humphrey Davy, the British electrochemist, established the existence of aluminium, and it was not until 17 years later that the Danish scientist Oersted produced the first tiny pellet of the metal.

The next step in the ″discovery″ of aluminium was the determination of its specific gravity by the German scientist Wöhler in 1845. He established one of aluminium's outstanding characteristics - lightness. He also discovered that it was easy to shape, was stable in air, and could be melted with a blow torch.

Research into aluminium then shifted to France. Experiments in production techniques enabled Henri Saint-Clair Deville to display a solid bar of the metal at the Paris Exhibition in 1855. But it cost him a fortune to produce, making aluminium more precious than gold, silver or platinum at that time. Napoleon III became enthusiastic about the possibilities of this new material, mainly for military purposes, and subsidised Deville in his efforts to find a low-cost method of production so that it could be made and used in large quantities. Deville was subsequently able to produce aluminium at a cost of 37 (£25) per kg but that was still too high to launch the metal commercially.

Thirty years later improvements in production methods made in association with Hamilton Y. Castner, an American chemist, had lowered the price to $18 (£12) per kg. The metal was still potentially plentiful and useful but, even at this substantially reduced price, too expensive for general use. The total annual output at this time was only 15 tonnes.

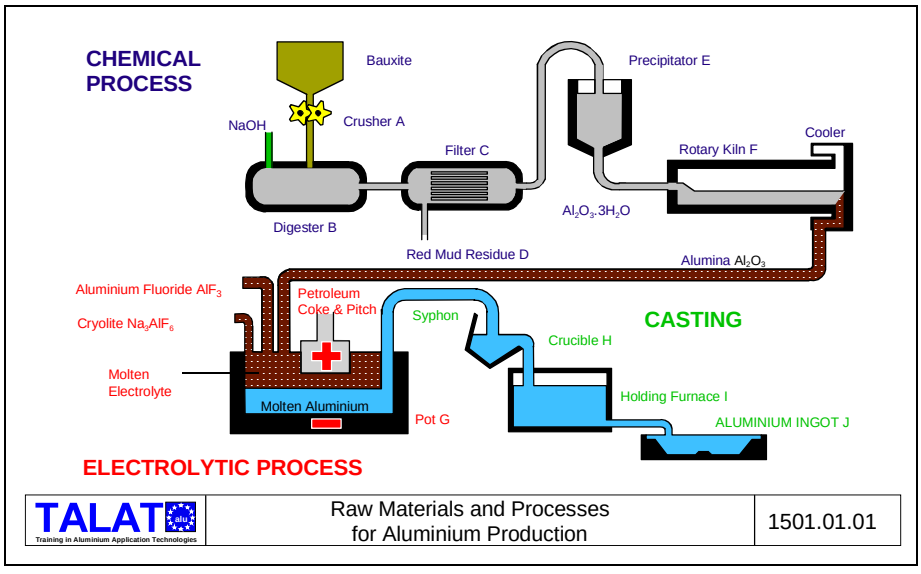
Then two unknown young scientists - Paul Louis Toussaint Héroult of France and Charles Martin Hall of the United States - took over the scientific search for the low-cost production of aluminium. They worked separately, each unaware of the other’s activities, in their respective countries. In 1886, after heart-breaking failures and little encouragement, the two scientists - almost simultaneously - came up with the same new process.

The scientists who preceded Héroult and Hall had been concerned entirely with a chemical process for producing the metal. Héroult and Hall introduced a new concept. They

believed that the answer to economic production lay in an electrolytic method. They had the idea that if some substance could be found which would conduct electricity and in which aluminium oxide (Al_2O_3), known as alumina, would dissolve, then an electric current passed through the solution could deposit the aluminium as metal.

There are some solutions which will dissolve aluminium, but these are aqueous (water) solutions. Unfortunately, water cannot be used because it would break down instead of the alumina when an electrical current is passed through it. There followed a long and intense search for a non-aqueous solution that would dissolve alumina. Both Hall and Héroult discovered that molten cryolite was the answer. Cryolite is a white translucent, sodium-aluminium fluoride material component found in its natural state only in Greenland. Most of the cryolite used in aluminium production today is synthetically produced.

Held at 1030°C, the molten cryolite dissolves up to 20% of alumina readily. The electrolytic cell holding the molten cryolite is a tank lined with carbon which serves as one electrode. Large carbon blocks inserted from the top of the bath act as the anode, or other electrode, and a heavy electrical current is passed between these two sets of electrodes through the solution. This current breaks down the alumina into aluminium and oxygen. The molten metallic aluminium collects at the bottom of the cell and is drained off every few days as sufficient metal accumulates (see **Figure 1501.01.01)**. The oxygen combines with the carbon at the anodes and is given off as carbon dioxide gas. This became the first industrially applied method of making the metal aluminium from alumina, and is the one still in use today.



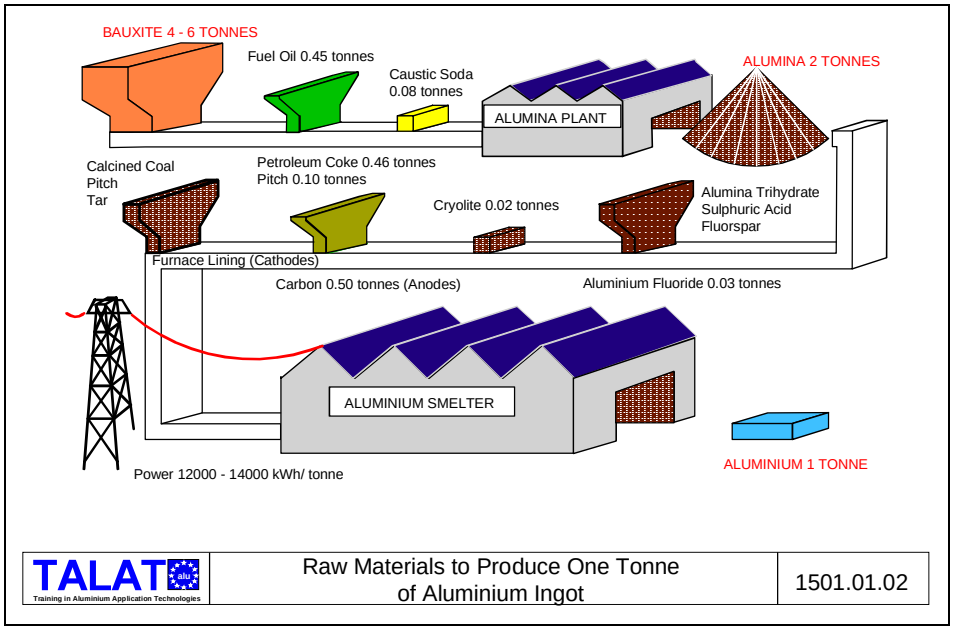
The immediate effect of the discovery of this process was to send the price of aluminium tumbling from $18 to $4.50 per kg, the first step in a downward course which has today established the selling price in terms of under two dollars per kg.
The first aluminium production companies were founded in 1888, two years after the electrolytic process was discovered - one each in France, the United States and

Switzerland. But the discoveries bringing about low-cost production did not lead directly to the widespread use of aluminium. Manufacturers, schooled in the traditions and skilled in the use of metals such as iron, copper and steel, were slow to capitalize on the potential benefits of this metal although it was known to be light, strong and highly resistant to corrosion. The first plant using the Héroult patent in fact produced aluminium bronze, for which there was a market. For many years after it became possible to make aluminium at a low price, it remained difficult to sell.

Alumina is produced in a totally separate first stage process from Bauxite ore. This (Bayer) chemical process starts by immersing crushed bauxite into a caustic soda solution which dissolves the alumina to form sodium aluminate liquor (**Figure 1501.01.01)**.

After filtering, the impurities are left behind as a "red mud" and the liquid is treated to precipitate the aluminium content out of the solution which is now in the form of aluminium hydroxide. This material is then separated from the liquor and changed to alumina, which resembles course granulated sugar, by heating in kilns at 1000°C. Approximately 4 kilogrammes of bauxite is required to produce 2 kilogrammes of alumina.

Although the process of manufacturing aluminium has changed little since the Héroult-Hall discovery the efficiency and environmental aspects have improved over the years. In today's modern plants 12 to 14 kilowatt hours of electricity and 2 kilogrammes of alumina would be required to produce 1 kilogramme of metal. A more detailed breakdown of the raw materials to produce a tonne of metal is shown in **Figure 1501.01.02**.



The Aluminium Industry Today

The production of primary aluminium is a young industry - just over 100 years old. But it has developed to the point where scores of companies in some 35 countries are smelting aluminium and thousands more are manufacturing the many end products to which aluminium is so well suited.

For its first half century the aluminium industry pursued the dual role of improving and enlarging production processes to reduce the price of the metal and, at the same time, proving the worth and feasibility of aluminium in a wide range of markets. Such was the dynamic approach of the industry to this problem that the consumption of aluminium gained the remarkable record of doubling every ten years. The strong demand for aluminium stimulated the rapid expansion of productive capacity to meet it.

The first World War had a dramatic effect on aluminium production and consumption. In the six years between 1914 and 1919 world output soared from 70,800 tonnes to 132,500 tonnes a year and it is a striking testimony to the adaptability of the metal that after the very large expansion occasioned by war the ground was held. Once the changeover to civilian production had been carried through the increased capacity was occupied before very long in supplying the normal demands of industry. And this happened again, on a much larger scale, as a result of the second World War.

World production of primary aluminium increased from 704,000 tonnes in 1939 to a peak of 1,950,000 tonnes in 1943, after which it declined considerably. At the end of World War II, the western world industry had completed an unprecedented threefold expansion in capacity in the space of four to five years. Civilian markets had to be developed for this new capacity. The demand for aluminium proved to be elastic and the expanded facilities were working at near capacity in a matter of a few years.

Constant research and product development throughout the 1950's, 60's and 70's led to an almost endless range of consumer goods incorporating aluminium. Its basic benefits of lightness, strength, durability, formability, conductivity and finishability made it a much sought after product.

The necessity for the industry itself to pioneer the use of aluminium led to an integrated structure in the major companies from the mining of bauxite to, in some cases, the finished consumer product. As the total world production soared, countries with raw materials and especially those with cheap energy resources, began to enter the market with primary metal for others to further the process. Today a significant proportion of metal is marketed in this way.

Recycled or Secondary Aluminium

Aluminium is relatively unique in being highly economic to recycle. Metal can be reclaimed and refined for further use at an **energy cost of only 5 per cent** of that required to produce the same quantity of aluminium from its ore. There has been a healthy ″secondary″ metal industry for many years and as refining techniques improve the use that can be made of reclaimed aluminium will increase from its present usage in Europe of 40% of all metal currently processed.

The most dramatic example of recycled metal is in the United States. In the USA of the one million tonnes of aluminium sheet used annually for beer and beverage cans, over 50% is supplied from used can scrap. Europe is now following this example with the building of dedicated aluminium can recycling plants.

1501.02 Important Physical Properties

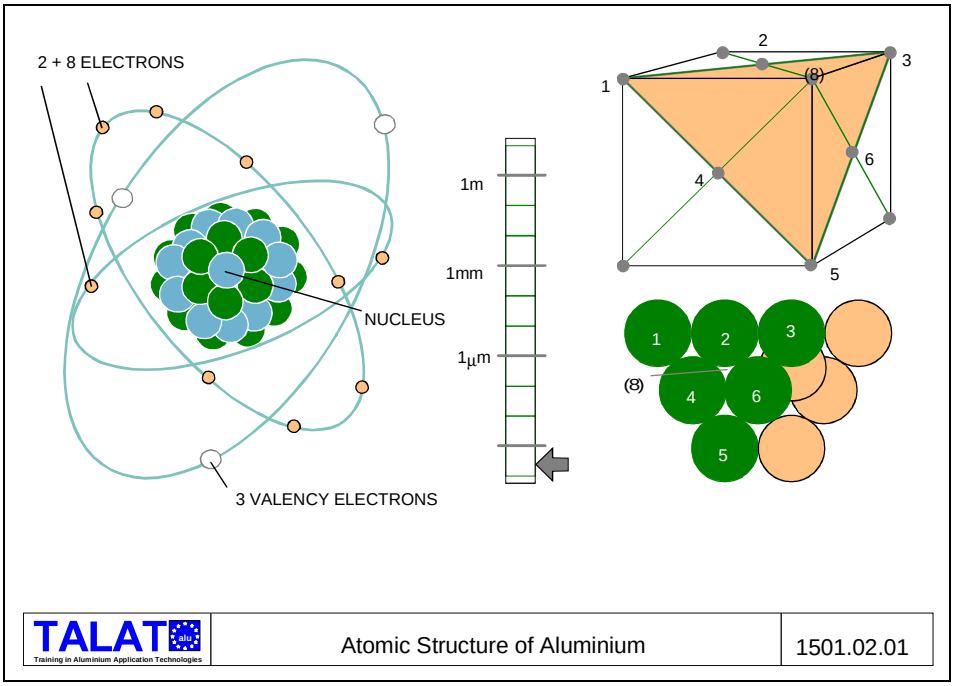
- Atomic structure
- Crystal structure
- Density
- Electrical conductivity and resistivity
- Non-magnetic property
- Thermal conductivity
- Reflectance and emissivity
- Corrosion resistance
- Thermal expansion
- Melting temperature
- Specific and latent heats

Atomic Structure

Aluminium is the third most plentiful element known to man, only oxygen and silicon exist in greater quantities. The element aluminium, chemical symbol Al, has the atomic number 13. According to present concepts, this means that an aluminium atom is composed of 13 electrons, each having a unit negative electrical charge, arranged in three orbits around a highly concentrated nucleus having a positive charge of 13. The three electrons in the outer orbit give the aluminium atom a valence or chemical combining power of +3 (see **Figure 1501.02.01)**.

Crystal Structure

When metals change from the molten to the solid state, they assume crystalline structures. The atoms arrange themselves in definite ordered symmetrical patterns which metallurgists speak of as "lattice" structures. Aluminium, like copper, silver and gold, crystallizes with the face-centred-cubic arrangement of atoms, common to most of the **ductile** metals. This means that the atoms form the corners of a cube, with one atom in the centre of each face (see **Figure 1501.02.01)**. The length of the sides of the cube for high purity aluminium has been determined as 4.049 x 10^{-8} cm, the shortest distance between two atoms in the aluminium structure is $\sqrt{2}$ divided by 2 x 4.049. The face centred cubic structure is one of the arrangements assumed by close packed spheres, in this case with a diameter of 4.049 x 10^{-8} cm, the corners of the cube being at the centre of each sphere.

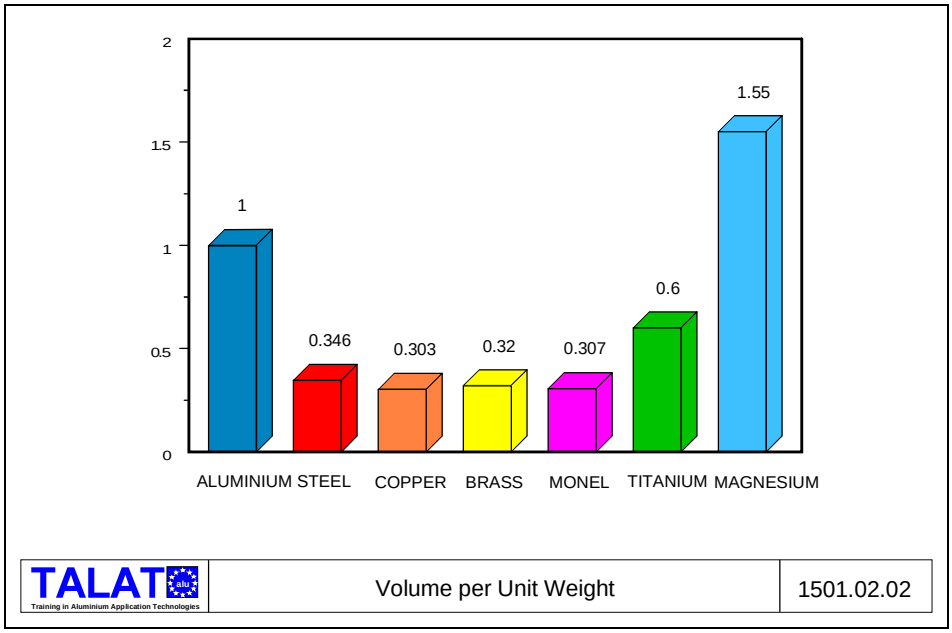


Density

Lightness is the outstanding and best known characteristic of aluminium. The metal has an atomic weight of 26.98 and a specific gravity of 2.70, approximately **one-third the weight of other commonly used metals**; with the exception of titanium and magnesium (see **Figure 1501.02.02**). As with most metals the density decreases with increasing temperature. The addition of other metals in the amounts commonly used in aluminium alloys does not appreciably change the density (plus 3%, minus 2%), (see e.g. also **Figure 1501.03.05**)**,** except in the case of Lithium alloys where the density of the alloy is reduced by up to 15%. Weight is important for all applications involving motion. Saving weight results in more payload or greater economy of operation. Saving weight also saves energy,

reduces vibration forces, improves the performance of reciprocating and moving parts, reduces tiredness when using manually operated equipment, offers lower shipping, handling and erection costs. Low weight combined with the high strength possible with special alloys has placed aluminium as the major material for aircraft construction for the past sixty years.

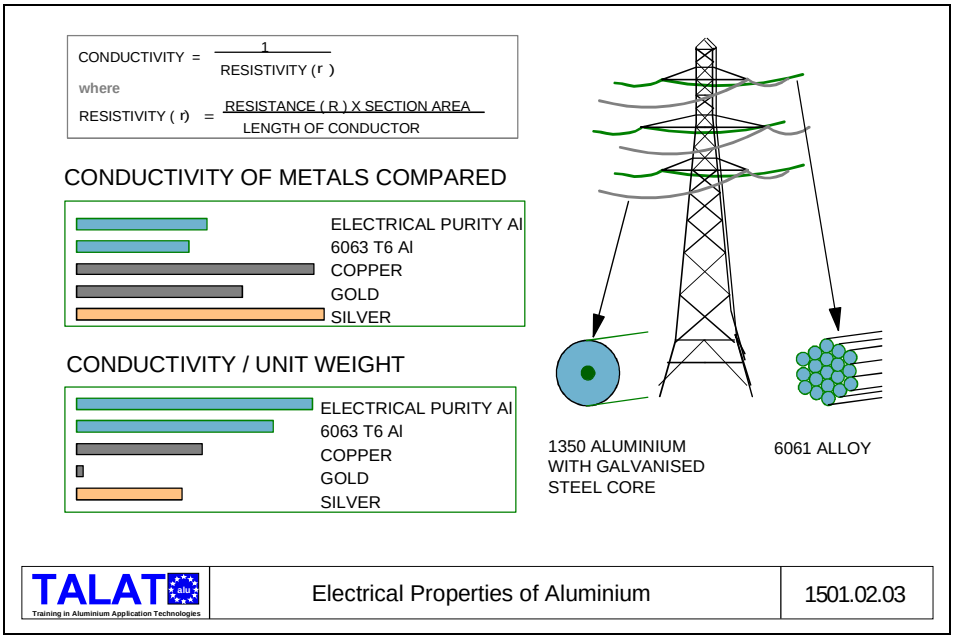
Although purchased on a weight basis, metals are generally used on a volume basis, it is therefore important to compare the cost of aluminium with other materials on this basis (**Figure 1501.02.02**).



Electrical Conductivity and Resistivity

The electrical conductivity of 99.99% pure aluminium at 20^0C is 63.8% of the International Annealed Copper Standard (IACS). Because of its low specific gravity, the mass electrical conductivity of pure aluminium is more than twice that of annealed copper and **greater than that of any other metal** (see **Figure 1501.02.03)**. The resistivity at 20^0C is 2.69 microohm cm. The electrical conductivity which is the reciprocal of resistivity, is one of the more sensitive properties of aluminium being affected by both, changes in composition and thermal treatment. The addition of other metals in aluminium alloys lowers the electrical conductivity of the aluminium therefore this must be offset against any additional benefits which may be gained, such as an increase in strength. Heat treatment also affects the conductivity since elements in solid solution produce greater resistance than undissolved constituents.

The very good electrical properties of aluminium have made it an obvious choice for applications in the electrical industry, particularly in power distribution where it is used almost exclusively for overhead transmission lines and busbars. The first major aluminium transmission line was completed in 1898 in the USA: a 46-mile, three-phase installation for the Standard Electric Company of California, from Blue Lakes to Stockton. Its use later became much more general when it was found possible to reinforce the cable (usually alloy 1350) with galvanised steel wire which increased the spans without too much sag. Although this product is still used, high strength (6061 type) all aluminium multi-strand cables are now preferred for some installations because higher line tensions can be achieved which can be applied to increase the distance between the pylons or alternatively reduce their height.



Non-Magnetic Property

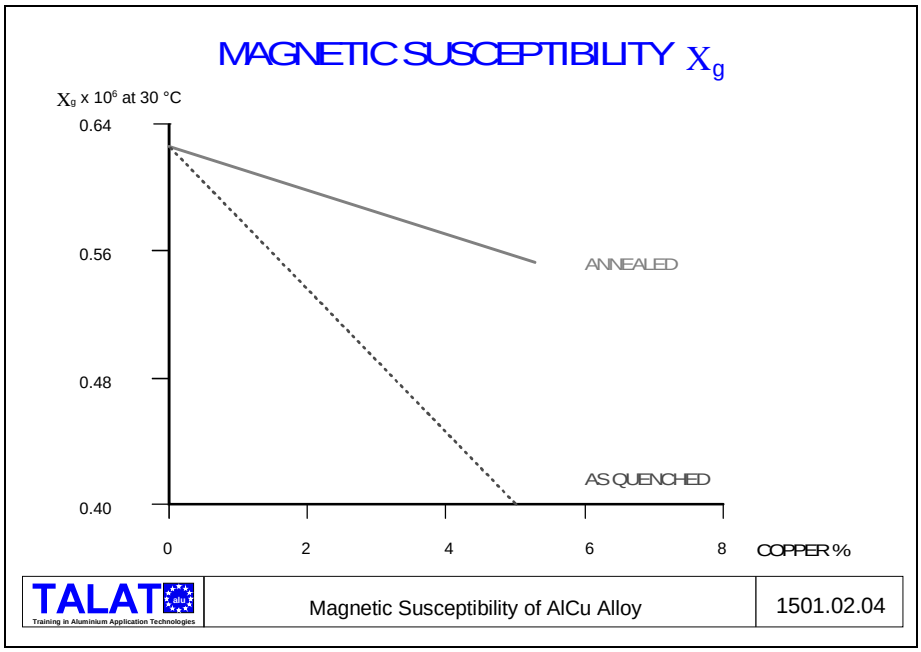
Aluminium and its alloys are very slightly paramagnetic, as it has a magnetic permeability (m) slightly greater than one. The magnetic susceptibility χ (Chi), degree of magnetization/ applied magnetizing force, of 99.99 % purity aluminium is only 0.623 x 10^{-6}, which for practical purposes is regarded as non magnetic (see **Figure 1501.02.04)**. The relationship between m and χ is given by : m = 1 + 4^χ. Chi is influenced by alloying as follows:

Cu decreases χ to 0.550 at 4.5% Cu (annealed)
Cu decreases χ to 0.400 at 4.5% Cu (quenched)
Fe in impurity quantities has no effect
($FeAl_3$ has the same Chi value as aluminium)

Mn increases χ to 0.959at 1.38% Mn
Cr increases χ to 0.669 at 0.63% Cr
V reduces χ to 0.582 at 0.36% V

The magnetic susceptibility is not sensitive to strain hardening, but varies slightly with temperature.

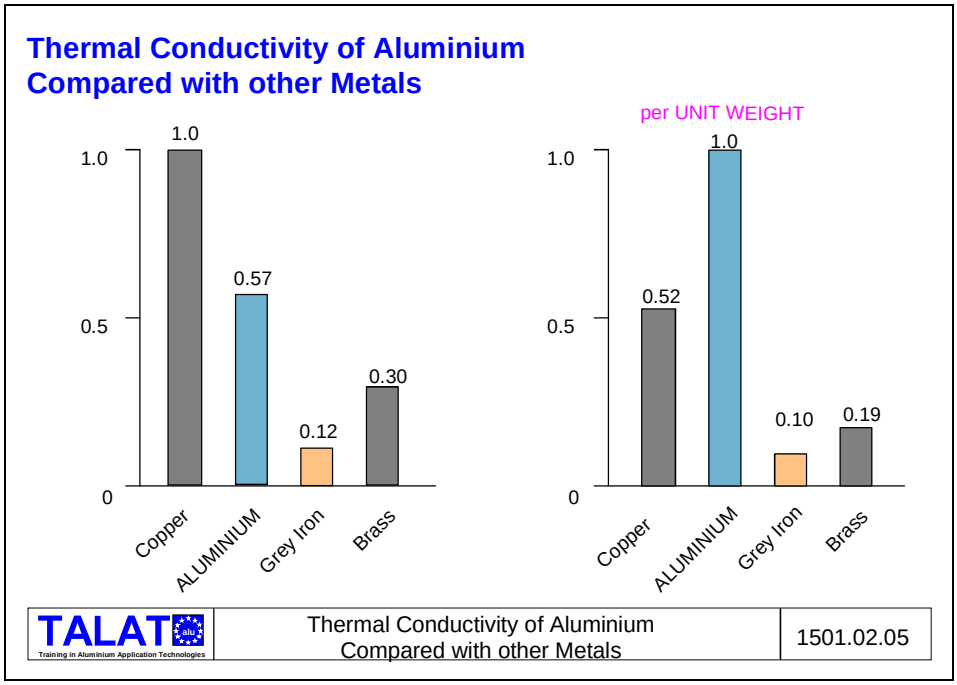
The low magnetic characteristic of aluminium is of value in military ship structures where it has advantages of lightness and lower cost over other non-magnetic metals. It is also used to advantage in electronic equipment for screening where it may also double as heat sinks, usually in the form of finned extruded profiles. The requirement for manufacturers of electronic equipment to ensure that their products comply with EEC directives on Electronic Compatibility, has also led to an increase in the application of vacuum deposited aluminium films on to plastic enclosures. Special techniques have been developed to deposit thick layers of aluminium without the need for protective lacquering; these give very good shielding results and the non-magnetic properties ensure consistent operation over the life of the product.



Thermal Conductivity

The thermal conductivity, κ, of 99.99% pure aluminium is 244 W/mK for the temperature range 0-100^{0}C which is 61.9% of the IACS, and again because of its low specific gravity its **mass thermal conductivity is twice that of copper** (see **Figure 1501.02.05**). Thermal conductivity can be calculated from electrical resistivity measurements using the formula $\kappa = 5.02\lambda T \times 10^{-9} + 0.03$, where κ is the thermal conductivity, λ is the electrical conductivity and T the absolute temperature in degrees Kelvin; this method is usually used to derive the values quoted in reference books. The thermal conductivity is reduced

slightly by the addition of alloying elements. Application of the formula has been found to be largely independent of composition with the exception of silicon. The combined properties of high thermal conductivity, low weight and good formability make aluminium an obvious choice for use in heat exchangers, car radiators and cooking utensils while in the cast form it is extensively used for I/C engine cylinder heads.



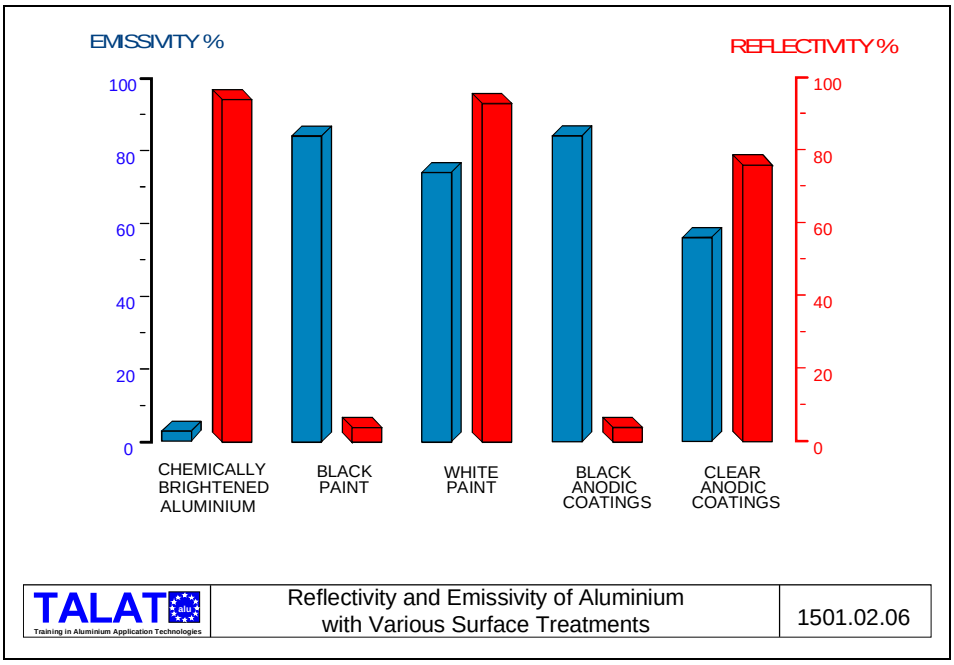
Reflectance and Emissivity

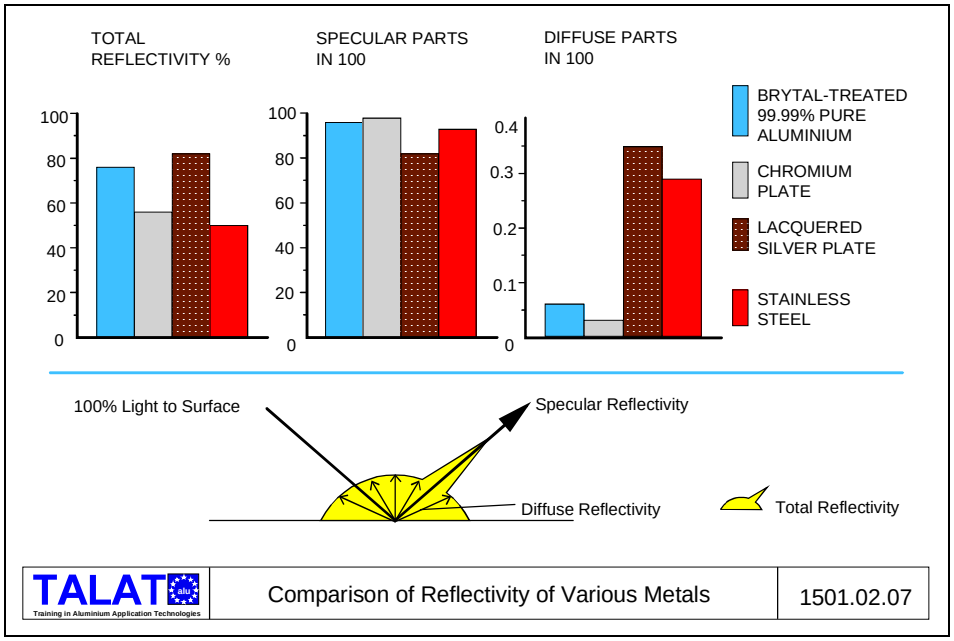
Emissivity, the ease with which a substance radiates its own thermal energy, is closely allied to reflectivity; the best reflecting surface being the poorest emitter, and conversely the worst reflecting surface being the best emitter. Plain aluminium reflects about 75% of the light and 90% of the heat radiation that falls on it. The emissivity of the same piece of aluminium is, however, low (< 10% of that of a black body at the same temperature and with the same surroundings).

The combined properties of high reflectivity and low emissivity give rise to the use of aluminium foil as a reflective insulating medium, either in dead air spaces or as a surface laminate combined with other insulating materials where it can also be arranged to provide the added benefit of an effective vapour barrier.

The emissivity of the aluminium surface can be raised considerably by anodic treatment and is therefore a process that is employed in the construction of heat exchangers. E.g. clear anodic coatings raise the emissivity to between 35 and 65%, the phosphoric and chromic acid methods being the most effective in this respect. Black anodic coatings have an even greater effect and raise it as high as 95%. **Figure 1501.02.06** shows the effect of various surface finishes on the emissivity of aluminium.

Super purity aluminium which has been mechanically polished, chemically brightened by the "Brytal" process and anodised > 3 microns (µm) thick will give a total reflectivity (brightness) of greater than 84% and a specular reflectivity (sharpness of mirror image) greater than 99% (see **Figure 1501.02.07)**.



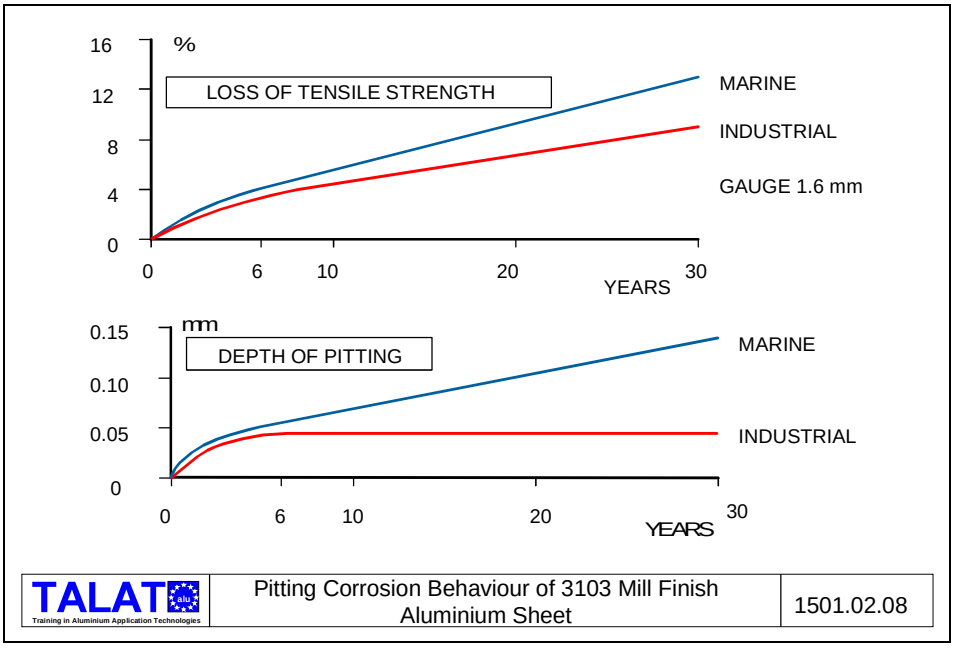


Even higher reflectivity is obtained by vaporizing the high purity aluminium in a vacuum and allowing it to re-condense on to glass or plastic surfaces. Aluminium coated mirrors

produced by this method are of particular interest to astronomers and in some ways are even more suitable than silver because they offer two important advantages. Firstly, an astronomical mirror coated with aluminium does not tarnish as quickly as silver and secondly, aluminium reflects ultra-violet light better. For these reasons the 60 and 100 inch mirrors of the Mount Wilson telescopes were "aluminized" as long ago as 1934.

Corrosion Resistance

Aluminium has a higher resistance to corrosion than many other metals owing to the protection conferred by the thin but tenacious film of oxide. This oxide layer is always present on the surface of aluminium in oxygen atmospheres. The graph (see **Figure 1501.02.08**) shows the degree of corrosion and its effect on strength in two different environments. The famous statue of Eros in London's Piccadilly Circus is an example of the corrosion resistance; after an inspection following eighty years of exposure to the London atmosphere, the statue showed only surface corrosion. The formation of the oxide is so rapid in the presence of oxygen that special measures have to be taken in thermal joining processes to prevent the oxide instantly forming while the process is being carried out.

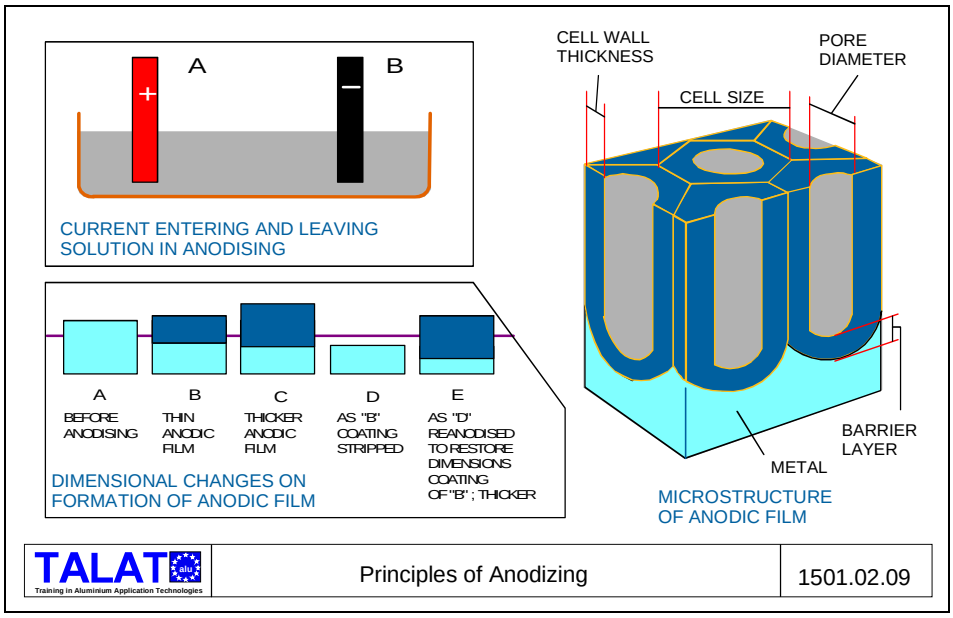


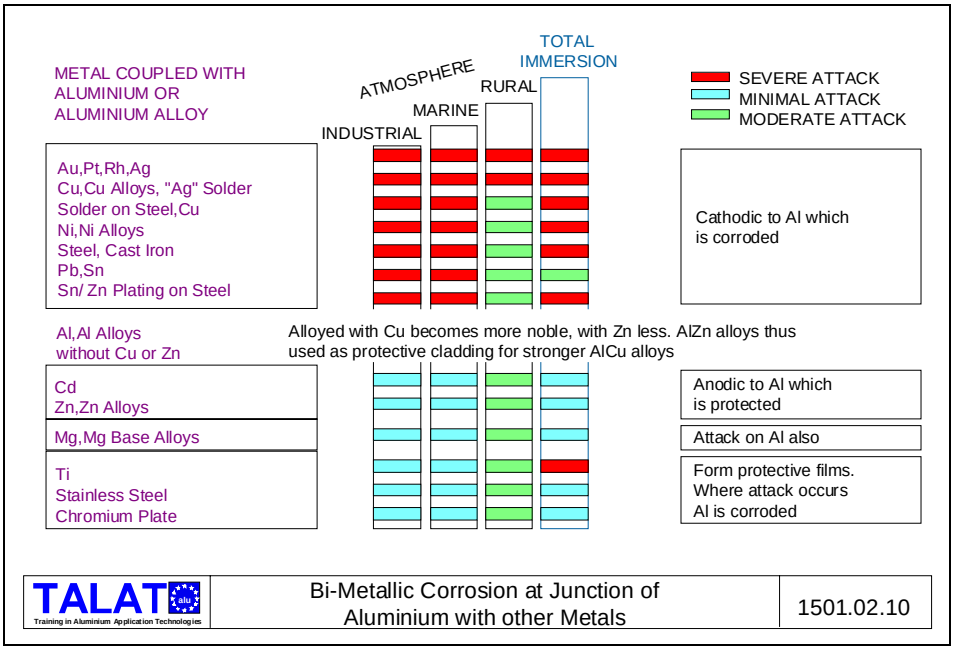
Aluminium is, however, a very reactive chemical element and its successful resistance to corrosion depends on the completeness with which the protective film of aluminium oxide prevents this underlying activity coming into play.

The film of oxide can be enhanced electrolyticly by a process called **"anodizing"**, in which the aluminium articles are suspended in a vat similar to that used for electroplating

but containing chromic, phosphoric or sulphuric acid solutions (**Figure 1501.02.09**). The anodic film also possesses the property of absorbing dyes thus enabling the metal to be tinted with attractive and enduring colours, thereby combining decoration with protection.

Nearly all engineering metals are cathodic to aluminium and its alloys, therefore aluminium becomes sacrificial in the presence of an electrolyte. Exceptions to this situation are magnesium, cadmium and zinc which are anodic; for this reason cadmium and zinc are often used as a protection between aluminium and the other metal. 18/8, 18/8/2 and 13% Cr Stainless steels, titanium and chrome plate are further exceptions since they have a high potential difference to aluminium but form there own protective films which considerably reduce bimetallic effects (see **Figure 1501.02.10**).

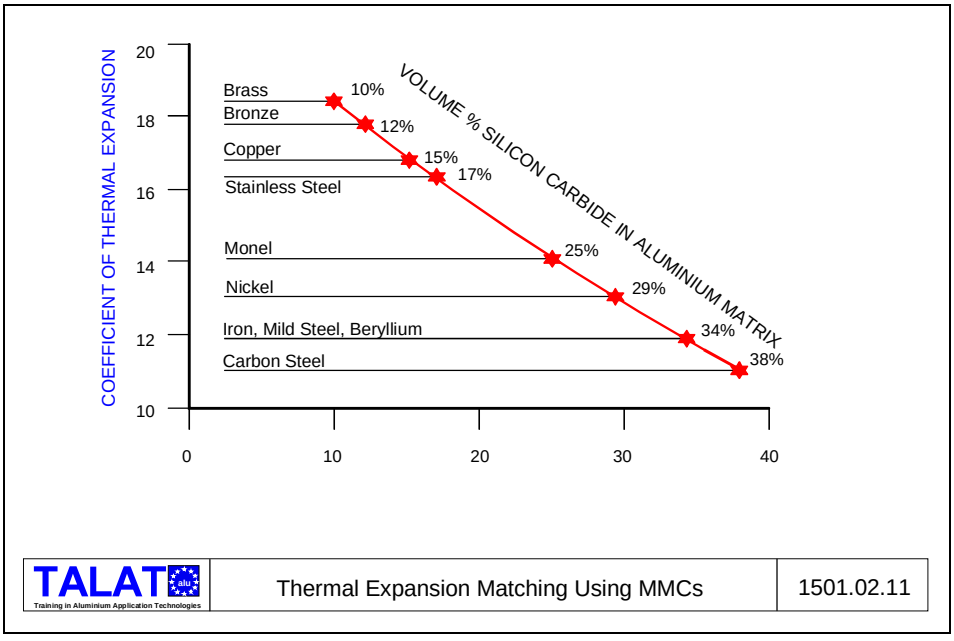




Thermal Expansion

The coefficient of thermal expansion is non-linear over the range from minus 200 to plus 600^0C but for practical purposes is assumed to be constant between the temperature range from 20 to 100^0C. The coefficient of thermal expansion of alloys is affected by the nature of their constituents: the presence of silicon and copper reduces expansion while magnesium increases it. For the common commercially used wrought alloys, the coefficient of expansion varies from 23.5 x 10^{-6} /K for 4.6% Cu aluminium alloy to 24.5 x 10^{-6} /K for 4.5 % Mg aluminium alloy, i.e. twice that of steel.

Some high silicon cast alloys specially developed for the manufacture of internal combustion engine pistons and cylinder heads have a coefficient of expansion as low as 16 x 10^{-6}/K while in some aluminium metal matrix composites the coefficient is reduced to 12.2 x 10^{-6}/K by the addition of 38% silicon carbide. Metal matrix composites are a comparatively recent development, and **Figure 1501.02.11** shows how the volume of silicon carbide can be changed to tailor the coefficient of expansion to match the common engineering metals.



The differential coefficient of expansion should be taken into consideration when aluminium is used in conjunction with other materials, e.g. large aluminium/steel structures. However, the stresses induced are moderated by aluminium's low elastic modulus which is one third that of steel. Only where dimensions are really large, and the structural members slender (laterally unstable) does the connection to steel pose a differential expansion problem. This would apply with curtain walls for high rise buildings and parapets for bridges where long slender aluminium extrusions are set on steel

frameworks. In these cases slip joints, plastic caulking and other stress-relieving devices are usually needed (see **Figure 1501.02.12**). In cases where the structure is stiff and unlikely to buckle such as an aluminium superstructure on a steel hulled ship all joints are now made rigid and the differential expansion is accepted as a compressive or tensile stress (**Figure 1501.02.12)**.

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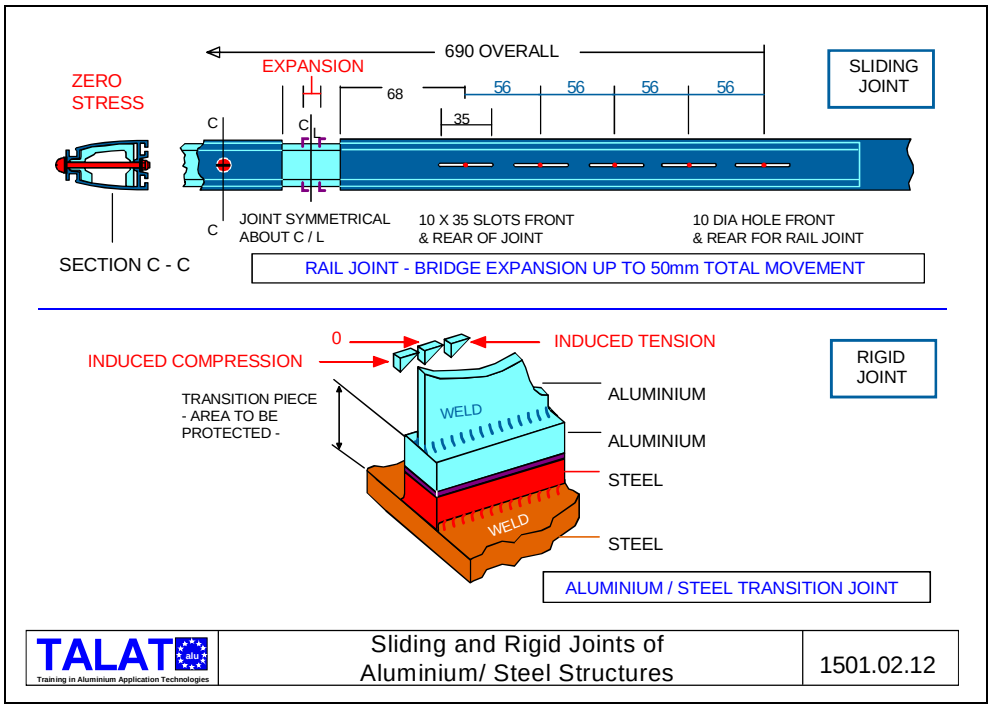
Another form of dimensional change, which does not directly affect the user of aluminium but is important in the production of castings, is the contraction of the metal on solidification; this is dependant upon alloy and is between 1 and 2% (comparative figures for iron, steel and brass are 1%, 2%, and 1.5%, respectively).

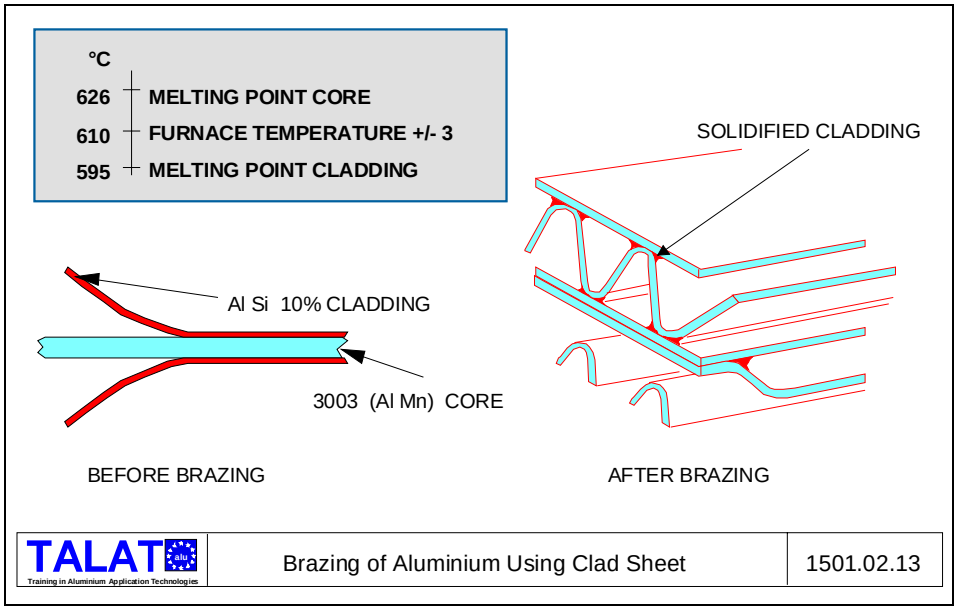


Melting Temperature

The melting point of aluminium is sensitive to purity, e.g. for 99.99% pure aluminium at atmospheric pressure it is 660^0C but this reduces to 635^0C for 99.5% commercial pure aluminium. The addition of alloying elements reduces this still further down to 500^0C for some magnesium alloys under certain conditions. The melting point increases with pressure in a straight line relationship to 980^0C at 50 kbar.

The difference between the melting points of two alloys of aluminium is used to advantage in the manufacture of aluminium heat exchangers, where the fins are made from aluminium-manganese (3103) or (3003) alloy clad with 5, 7.5% or 10% silicon alloy. The assembled heat exchanger is heated to the temperature which will just melt the cladding while allowing the core to remain solid; this causes the molten cladding alloy to flow by

capillary action to the joints which become structural on cooling (**Figure 1501.02.13**). The highly controlled heating necessary in this brazing process is done using either a vacuum furnace, controlled atmosphere furnace, or flux bath.



Specific and Latent Heats

Aluminium has a relatively high specific heat when compared with other metals on a weight basis, i.e. 921 J/kg at 100^0C which is higher than that of any common metal except magnesium (1046); iron and steel are about 500 and copper and brass 377. On a volume basis, however, the heat capacity of aluminium is less than any of the heavier metals.

1501.03 Aluminium Alloy Availability

- The four digit system for wrought alloy identification
- Alloy systems
  - Unalloyed aluminium
  - Aluminium-copper alloys
  - Aluminium-manganese alloys
  - Aluminium-silicon alloys
  - Aluminium-magnesium alloys
  - Aluminium-magnesium-silicon alloys
  - Aluminium-zinc-magnesium and aluminium-zinc-magnesium-copper alloys
  - Aluminium-plus other elements which do not fall into any of the patterns outlined above
- The five digit system for cast alloy identification
  - Unalloyed aluminium

- Aluminium alloys, ingots and casting

Aluminium is the backbone of the aerospace industry, is used to assist with cooking and packaging, assist in the manufacture of high grade steel and is the base for a versatile paint. Aluminium is a light and attractive metal exhibiting a high degree of corrosion resistance in normal corrosive environments. It is also soft, hard, easy to weld, difficult to weld, and a host of other seemingly conflicting characteristics.

If this sounds confused, it is. The properties of a particular aluminium product depend on the alloy chosen. The term aluminium refers to a family of alloys. Knowledge of these alloys is the key to the effective use of aluminium.

Outlined below is the family of aluminium alloys which are readily available commercially.

The Four Digit System for Wrought Alloy Identification

As a major step towards alignment of Aluminium and Aluminium Alloy compositions on an international basis, most countries have agreed to adopt the 4 digit classification for wrought alloy composition designation. This system is administered by the Aluminium Association (AA), Washington USA, who compile the ″Registration record of International Alloy Designations and Chemical Composition Limits for Wrought Aluminium Alloys″. The European reference for the alloys will be identified with the preface EN and AW which indicated European Normative Aluminium Wrought alloys. In all other respects the alloy numbers and composition limits are identical to those registered by the Aluminium Association (**Figure 1501.03.01**).

Aluminium Alloy Designation System (CEN)

		Major alloying element	Atoms in solution	Work hardening	Precipitation hardening	
WROUGHT ALLOYS*) EN AW-	1XXX	None (min. 99.00% Al)		X		
	3XXX	Mn	X	X		Non-heat treatable alloys
	4XXX	Si	X	X		
	5XXX	Mg	X	X		
	2XXX	Cu	X	(X)	X	Heat treatable alloys
	6XXX	Mg + Si	X	(X)	X	
	7XXX	Zn	X	(X)	X	
	8XXX	Other	X	(X)	X	

CASTING ALLOYS*) EN AB- EN AC- EN AM-	1XXX0	None (min. 99.00% Al)
	2XXX0	Cu
	4XXX0	Si
	5XXX0	Mg
	7XXX0	Zn
	8XXX0	Sn
	9XXX0	Master Alloys

*) letters preceding the alloy numbers have the following meaning
EN = European Standard
A = Aluminium
B = Ingot
C = Cast Alloy
M = Master Alloy
W = Wrought Alloy

Sources: according to EN 573; prEN 1780

TALAT Training in Aluminium Application Technologies | Aluminium Alloy Designation System | 1501.03.01

The first of the four digits in the designation indicates the alloy group in terms of the major alloying elements, viz,

1XXX Aluminium of 99,00% minimum purity and higher
2XXX Copper
3XXX Manganese
4XXX Silicone
5XXX Magnesium
6XXX Magnesium and Silicon
7XXX Zinc
8XXX Other elements
9XXX Unused series

1XXX Group. In this group for minimum purities of 99,00% and greater, the last two of the four digits indicate the minimum percentage of aluminium. For example, 1070 indicates aluminium purity of 99,70%.

The second digit indicates modifications in impurity limits or alloying elements. If the second digit is zero it indicates unalloyed aluminium having natural impurity limits; integers 1-9 indicated special control of one or more individual impurities or alloying elements. For example, 1145 indicates aluminium of 99,45% minimum purity with the second digit 1 indicating special control of Iron and Silicon.

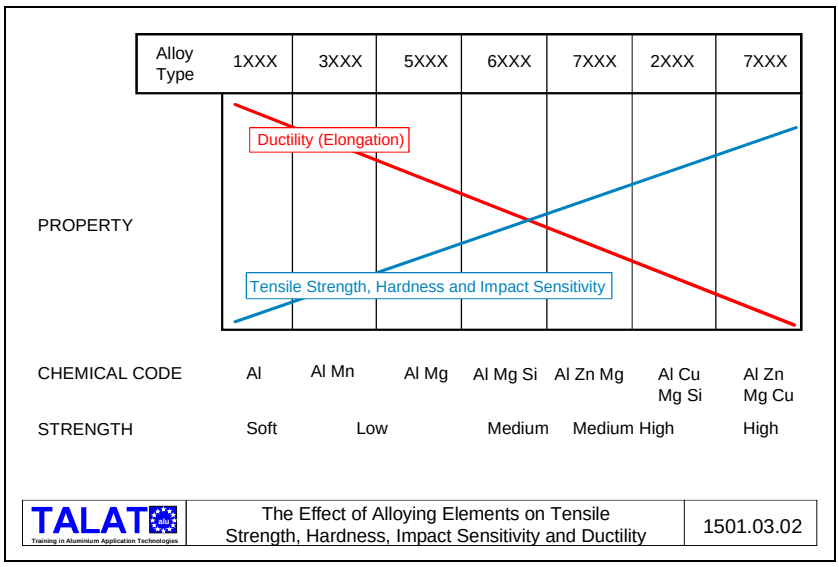
2XXX to
8XXX Groups

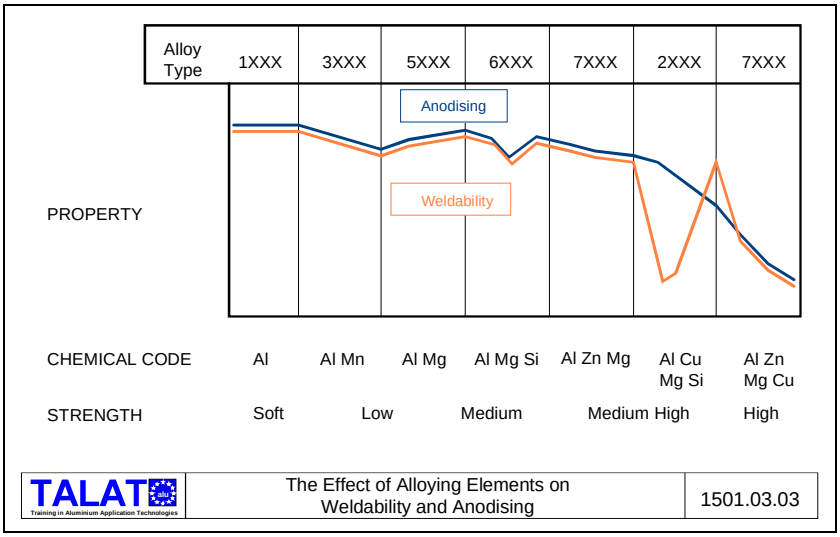
In these groups the last two of the four digits have no special significance but serve only to identify the different alloys in the group. The second digit indicates alloy modifications; if it is zero it indicates the original alloy.

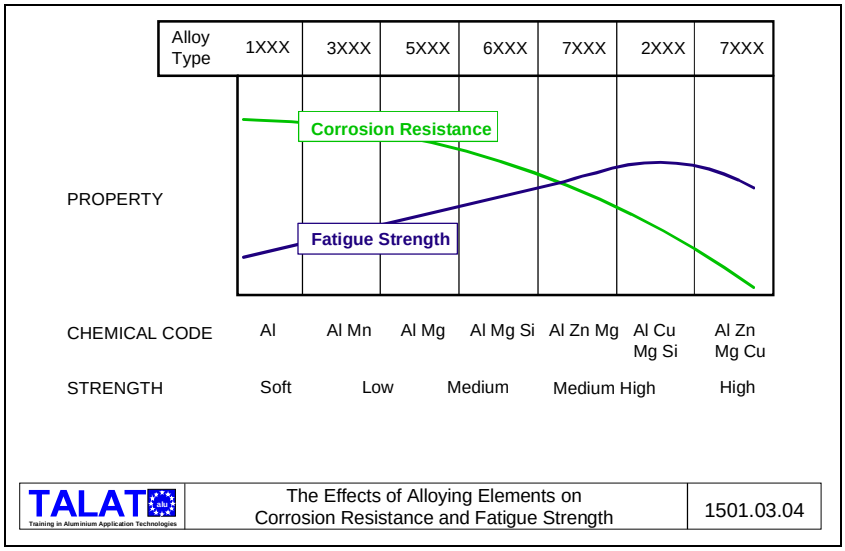
National variations consisting of minor changes in the chemical composition of a standard alloy are accepted in the international system and are identified by a suffix letter after the numerical designation, e.g. 6101A. Experimental alloys are indicated by the prefix X, eg. X2030.

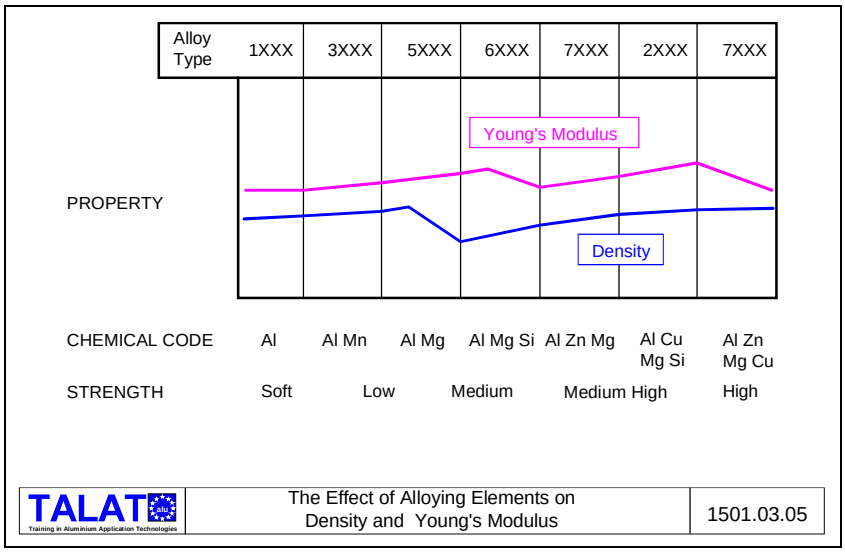
Alloy Systems

Figures 1501.03.02 - 05 inclusive show the relationship between the properties and characteristics of the various alloy groupings. For instance, natural, unalloyed aluminium possesses an ultimate tensile strength of about 70 Mpa which compares to 700 MPa and above for some of the 7XXX series (**Figure 1501.03.02**).




Alloy Type
1XXX
3XXX
5XXX
6XXX
7XXX
2XXX
7XXX
Anodising
Weldability
PROPERTY
CHEMICAL CODE
Al
Al Mn
Al Mg
Al Mg Si
Al Zn Mg
Al Cu Mg Si
Al Zn Mg Cu
STRENGTH
Soft
Low
Medium
Medium High
High
TALAT
Training in Aluminium Application Technologies
The Effect of Alloying Elements on Weldability and Anodising
1501.03.03


Alloy Type
1XXX
3XXX
5XXX
6XXX
7XXX
2XXX
7XXX
Corrosion Resistance
Fatigue Strength
PROPERTY
CHEMICAL CODE
Al
Al Mn
Al Mg
Al Mg Si
Al Zn Mg
Al Cu Mg Si
Al Zn Mg Cu
STRENGTH
Soft
Low
Medium
Medium High
High
TALAT
Training in Aluminium Application Technologies
The Effects of Alloying Elements on Corrosion Resistance and Fatigue Strength
1501.03.04


Alloy Type
1XXX
3XXX
5XXX
6XXX
7XXX
2XXX
7XXX
Young's Modulus
Density
PROPERTY
CHEMICAL CODE
Al
Al Mn
Al Mg
Al Mg Si
Al Zn Mg
Al Cu Mg Si
Al Zn Mg Cu
STRENGTH
Soft
Low
Medium
Medium High
High
TALAT
Training in Aluminium Application Technologies
The Effect of Alloying Elements on Density and Young's Modulus
1501.03.05

Wrought aluminium alloys are those in which the cast ingot is mechanically worked by processes such as rolling, drawing, extruding or forging, These alloys fall into several groups; each group being distinguished by one main alloying constituent, as outlined in further detail below. All wrought alloys are further divided into two general classes namely the "heat-treatable" and "non-heat treatable" alloys.

Unalloyed Aluminium

EN system EN AW-1xxx e.g. 1200

Commercially pure aluminium (99.0% pure) is soft, ductile and of little structural value, but as extracted it normally contains up to 1.5% impurities; mainly iron and silicon. These have a marked effect on the properties of the metal, so that, with the further hardness acquired during rolling, commercial purity aluminium has a useful degree of strength and is widely produced in sheet form. It is very ductile in the annealed condition, has excellent corrosion resistance and is ideal for use in the food and chemical industries. It is rolled to foil thickness for use in food, confectionery and cigarette packaging and has even been used for making shaped panels for vehicles where its high elongation was of prime importance for the forming processes involved.

Aluminium - Copper Alloys

EN system EN AW - 2XXX e.g. 2014

With copper as the principle element, these alloys require solution heat treatment to achieve optimum mechanical properties, which can exceed that of mild steel.

A typical example here is 2014, a composition of

Cu	Si	Mn	Mg
4,0-4,58	0,6-0,9%	0,4-1,2%	0,5-0,9%

giving typical tensile properties of 460 Mpa.

This group of alloys with additions such as Pb (X2030) or Pb + Bi (2011) give the best machinability but there is a trend to avoid these additions because of potential scrap contamination. Typical alloys in this group are 2017, 2024, 2014 X2030 and 2011. Generally, these alloys have limited cold formability, except in the annealed condition, and less corrosion resistance than other alloys; they are therefore generally anodised for protection from aggressive environments. They are also more difficult to weld. Alloys in this family are particularly useful for aircraft and military applications.

Aluminium - Manganese Alloys

EN system EN AW - 3XXX e.g. 3004

The addition of approximately 1% manganese increases the strength by approximately 10 - 15% compared with 1200, without any major loss in ductility. This non-heat treatable alloy generally finds a wide application where greater strength than 1200 is required without any major loss in corrosion. Major end uses of the common alloys in this range include roofing sheet (3105 + 3103) and vehicle panelling (3103).

Aluminium - Silicon Alloys

EN system EN AW 4XXX eg 4043

Silicon can be added to aluminium alloys in quantities sufficient to cause a substantial lowering of the melting point. For this reason this alloy system is used entirely for welding wire and brazing filler alloys, where melting points lower than the parent metal are required. In themselves these alloys are non-heat-treatable but in general they pick up enough of the alloy constituents of the parent metal to respond to a limited degree of heat treatment.

Aluminium - Magnesium Alloys

EN system EN AW 5XXX eg 5056

This series of alloys is non heat-treatable and exhibits the best combination of high strength with resistance to corrosion (as indicated by its frequent use in marine/sea water applications). This series also exhibits good weldability but when the Mg level exceed 3% there is a tendency for stress corrosion resistance to be reduced, dependent on the temper used and temperature of operation. Uses: pressure vessels, bulk road and rail vehicles, ships structures, chemical plant.

Aluminium - Magnesium - Silicon Alloys

EN Systems EN AW - 6XXX eg 6063

This group of heat-treatable alloys uses a combination of magnesium and silicon (magnesium Silicide) to render it heat-treatable. These alloys find their greatest strength, combined with good corrosion resistance, ease of formability and excellent ability to be anodised. Typical alloys in this group include 6061, 6063 and 6082 used for building structure applications, and land and see transport applications.

Aluminium-Zinc-Magnesium and Aluminium-Zinc-Magnesium-Copper Alloys

EN Systems EN AW - 7XXX eg 7075

This group of alloys exhibits the highest strength as far as aluminium is concerned and in many cases they are superior to that of high tensile steels.

It is the combination of zinc and magnesium which makes the 7XXX alloys heat-treatable and gives rise to their very high strength. A typical example here is 7075 with a composition of:

Zn	Mg	Cu
5,0-6,0%	2,0-3,0%	1,0%-2,0%

giving a typical tensile strength of 580Mpa. This group of alloys is, however, relatively difficult to fabricate and requires a very high degree of technology to produce. It is mainly used in military applications.

Aluminium - plus other elements which do not fall into any of the patterns outlined above

EN System EN AW - 8XXX e.g. 8011,

a totally mixed bag of alloys ranging from 8011 for bottle capping to 8091 for Lithium alloy aircraft sheet.

The Five Digit System for Cast Alloy Identification

The new European reference for alloys will be identified with the preface EN followed by a blank space followed by A which indicates aluminium then B,C, or M which indicate respectively ingots for re-melting, casting or master alloys.

The cast alloy numbering system for Europe, **Figure 1501.03.01,** will use a five figure format as follows:

Unalloyed Aluminium

The first of the five figures in the designation system is the number 1 (as used in wrought aluminium for aluminium for aluminium 99,00% minimum and greater).

The second of the five figures in the designation system is the number 0.

The third and fourth figures indicate the minimum aluminium percentage. They are the same as the two figures to the right of the decimal point in the minimum percentage, when it is expressed to the nearest 0.01 percent.

Example AB-10 97 0 for Al 99, 97

The fifth figure is 0, 1 or 2 depending on the application being general or specific.

Aluminium Alloys, Ingots and Casting

For a given alloy, ingot and casting have the same numerical designation. The first of the five figures in the designations indicates the major alloying element and is the same as that used in the wrought aluminium system.

- Copper 2XXX

- Silicon 4XXX
- Magnesium 5XXX
- Zinc 7XXX

The second of the five figures in the designation indicates the alloy group.

-2 | 1 | XXX : A1Cu

-4 | 1 | XXX : A1SiMgTi

-4 | 2 | XXX : A1Si7Mg

-4 | 3 | XXX : AlSi10Mg

-4 | 4 | XXX : A1Si

-4 | 5 | XXX : AlSiCu

-4 | 6 | XXX : AlSi9Cu

-4 | 7 | XXX : AlSi (Cu)

-4 | 8 | XXX : AlSiCuNiMg

-5 | 1 | XXX : AlMg

-7 | 1 | XXX : AlZnMg

The third figure is arbitrary.
The fourth figure is generally 0.
The fifth figure is always 0 for CEN alloys and never 0 for AECMA alloys.

1501.04 Basic Physical Metallurgy

- Work hardening
- Dispersion hardening
- Solid solution hardening
- Precipitation hardening
- Temper designations non heat-treatable alloys
- Temper designations heat-treatable alloys
- Common alloys and applications

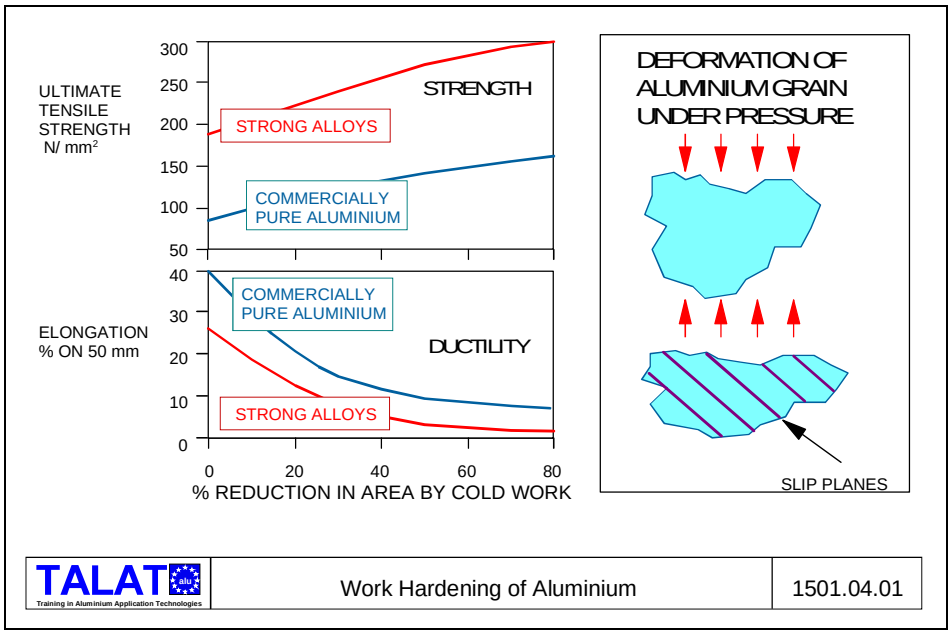
There are four basic ways in which aluminium can be strengthened: work hardening, dispersion hardening, solid solution hardening and precipitation hardening.

These hardening processes are effective because they produce conditions that impede the movement of dislocations. Dislocations are faults that enable metal crystals to slip at stresses very much below those that would be required to move two perfect crystal planes past one another.

Work Hardening

Whenever aluminium products are fabricated by rolling, extruding, drawing, bending, etc., work is done on the metal. When work is done below the metal's recrystallisation temperature (cold work), it not only forms the metal, but also increases it strength due to the fact that dislocations trying to glide on different slip planes interact causing a "traffic jam" that prevents them from moving. Fabricating processes carried out above the metal's recrystallization temperature (hot work) do not normally increase strength over the annealed strength condition.

With non heat-treatable wrought alloys, cold work is the only way of increasing strength. With heat treatable alloy, cold work applied after heat treating can increase strength still further. Work hardening of non heat treatable aluminium magnesium and pure aluminium alloy is shown in **Figure 1501.04.01**.



Dispersion Hardening

Fine particles of an insoluble material are uniformly distributed throughout the cristal lattice in such a way as to impede the movement of dislocations (eg 3000 series). With aluminium, dispersion-hardening may be achieved in two ways:

- by the addition of alloying elements that combine chemically with the metal or each other to form fine particles that precipitate from the matrix

- by mixing particles of a suitable substance (for example $A1_20_3$) with powdered aluminium and then compacting the mixture into a solid mass.

Solid Solution Hardening

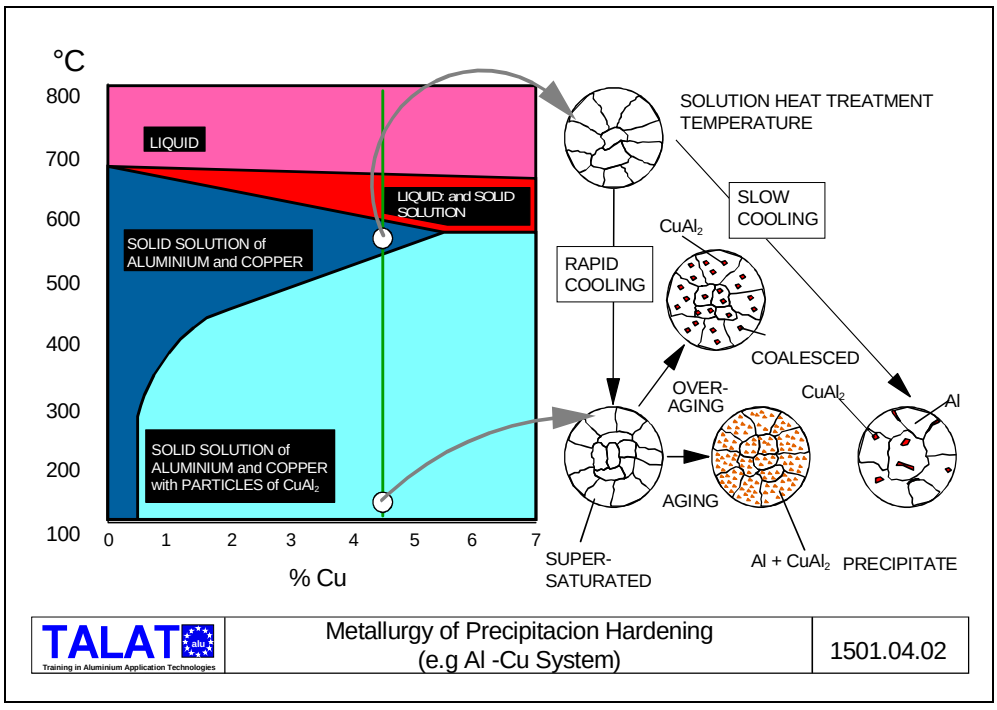
Most alloys are solid solutions of one or more metals dissolved in another metal: either the alloying of atoms take over the lattice positions of some of the base-metal atoms (substitutional solid solutions) or they occupy spaces in the lattice between the base-metal (interstitial solid solutions). In both cases, the base-metal lattice is distorted, retarding the movement of dislocations and hence strengthening the metal. The 5000 series with magnesium as the solute is a good example.

Most aluminium alloys reflect some solid solution hardening as a result of one or more elements being dissolved in the aluminium base, each element's contribution to the strength of the alloy is roughly additive. Usually these alloys are further strengthened by heat treatment or by work hardening.

Precipitation Hardening

Precipitation hardening is a two stage heat treatment. It can be applied only to those groups of alloys which are heat treatable (i.e. 2000, 6000 and 7000 wrought series). Firstly, a supersaturated condition is produced by solution heat treatment. Secondly the "ageing" process that occurs after quenching may be accelerated by heating the alloy until a second and coherent phase is precipitated. This coherent phase strengthens the alloys by obstructing the movements of dislocations.

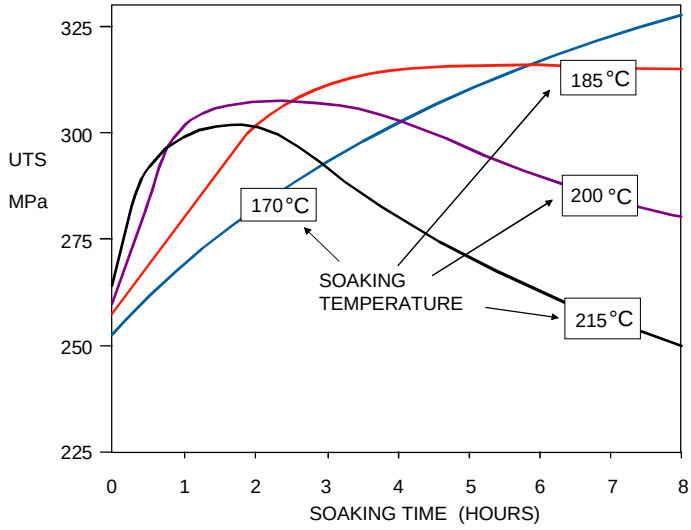
Solution treatment involves heating the alloy to a temperature just below the lowest melting point of the alloy system, holding at this temperature until the base metal dissolves a significant amount of the alloying elements (**Figure 1501.04.02)**. The alloy is then rapidly cooled to retain as much of the alloying elements in solution as possible and so produce a supersaturated solid solution. This supersaturated condition is usually unstable and therefore heat-treatable alloys are used in this condition, i.e. T4.



After solution heat-treatment most heat-treatable alloys exhibit some age-hardening at room temperature. The rate and extent of natural age-hardening at room temperature varies from alloy to alloy. For example, 2024 reaches a stable condition in four days and is therefore widely used in naturally aged tempers. By contrast, 7075 and most other aluminium-zinc-magnesium-copper alloys continue to age-harden indefinitely at room temperature and are seldom used in naturally aged temper.

Heating above room temperature accelerates the precipitation reaction, in practice, therefore, precipitation-hardened alloys are usually ″artificially aged' (precipitation heat treated) to develop maximum properties as quickly as possible. The temperature range within which control of the precipitation reactions is feasible is 120-180°C. The actual temperature depends on such variables as the alloy, the properties desired and production schedule.

An aluminium alloy that responds to precipitation hardening must contain amounts of soluble alloying elements that exceed the solid solubility limit at room temperature. **Figure 1501.04.02**. shows one corner of the phase diagram of such an alloy. In addition, the alloy must be able to dissolve the excess of soluble alloying elements and then to precipitate them (or the compounds they form) as distinctive constituents within the crystal lattice. The constituents precipitated must have a structure different from the solid solution. Careful control of this precipitation reaction is essential, otherwise the hardening constituents become too coarse and contribute little to the strengthening. The effect of time and temperature on the precipitation process is shown in **Figure 1501.04.03**.



TALAT Training in Aluminium Application Technologies | Ageing-Curves for Aluminium Alloy 6082 | 1501.04.03

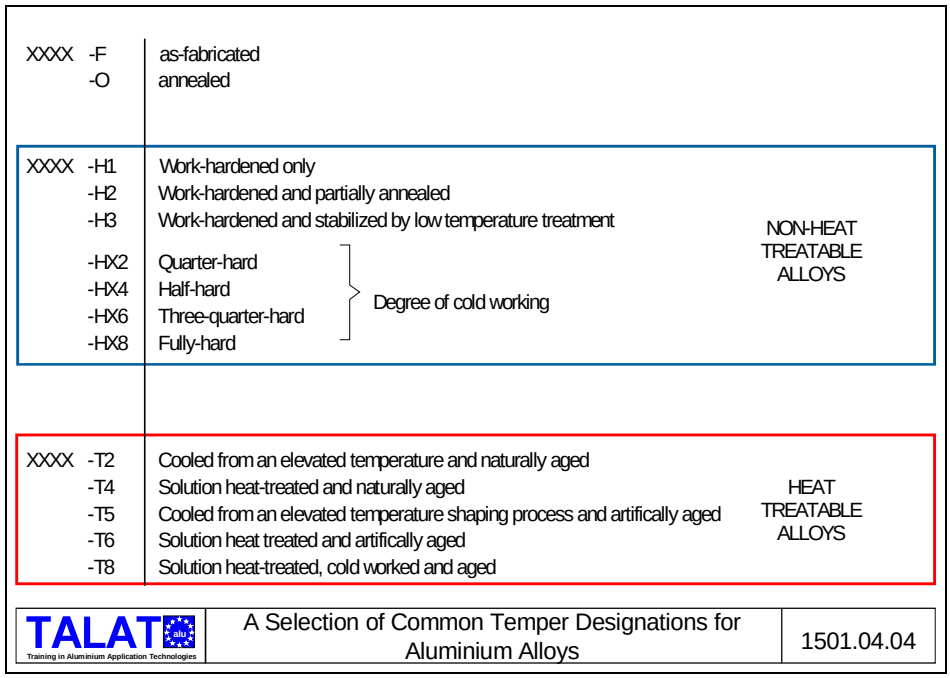
Temper Designations Non Heat-Treatable Alloys

These are alloys in which the mechanical properties may be enhanced by the amount of cold work introduced after the last annealing operation. The properties so obtained will be reduced by subsequent heating and cannot be restored except by additional cold work.

In the non heat-treatable alloys there are generally six available tempers (**Figure 1501.04.04)**. It should be remembered, however, that all tempers are not always available for all alloys. The most common tempers range from annealed, designated by ″0″, to the full-hard tempers designated by temper HX8. The term H8 refers to the maximum amount of cold work which is commercially practical for the particular alloy. An alloy in the HX8 condition will exhibit a 75% increase in strength over the same alloy in the ″0″ condition. Between the annealed and the HX8 state there are generally three intermediate levels of hardness referred to as:

Quarter hard	HX2
Half hard	HX4
Three quarters hard	HX6

Products are produced in the ″F″ temper, are defined as "as fabricated". ″F″ represents an undefined strength enhancement above the annealed state ″0″.



Temper Designations Heat-Treatable Alloys

These are alloys in which the mechanical properties may be changed by heat treatment. Heat is used to enhance strength but can also be used to decrease strength through annealing to assist with forming; these alloys can also be re-heat-treated after annealing or forming to restore their original properties, This is a major difference compared with non heat-treatable alloys (**Figure 1501.04.04).**

The major tempers in this area are designated and defined according to international standards (AA, ISO, CEN):

0	Fully annealed
T3	Solution heat-treated, cold worked out, naturally aged
T4	Solution heat-treated and naturally aged
T5	Cooled from an elevated temperature shaping process and then artificially aged
T6	Solution heat-treated, artificially aged
T8	Solution heat-treated, cold worked and artificially aged

The T4 is produced by "solution heat treatment" which, as mentioned previously, consists of heating the alloy to a predetermined temperature just below its melting point, at which point some of the alloy constituents dissolve and are then taken into what is referred to as "solid solution". To ensure that this situation is maintained the material is quenched rapidly. An example of this is 2014 where the temperature is raised to 500°C ± 5% before quenching in water.

Common Alloys and Applications

The following list gives a brief survey of commonly used aluminium alloys, their characteristics and common uses:

Alloy	Alloy Characteristics	Common Uses	Form
1050/ 1200	Non heat-treatable. Good formability, weldability and corrosion resistance	Food and Chemical Industry	S.P
2014A	Heat-treatable. High strength. Non-weldable. Poor corrosion resistance	Airframes	E.P
3103/ 3003	Non-treatable. Medium strength work hardening alloy. Good weldability, formability and corrosion resistance.	Vehicle panelling, structures exposed to marine atmospheres, mine cages	S.P.E
5251/ 5052	Non-heat-treatable. Medium strength work hardening alloy. Good weldability, formability and corrosion resistance.	Vehicle panelling, structures exposed to marine atmospheres, mine cages.	S.P
*5454	Non-heat-treatable. Used at temperatures between 650°C and 200°C. Good weldability and	Pressure vessels, road and rail tankers. Transport of Ammonium Nitrate, Petroleum tankers, Chemical plants.	S.P
*5083/ 5182		Pressure vessels and road transport	S.P.E

	corrosion resistant. Non-heat-treatable. Good weldability and corrosion resistance.	applications below 65°C. Shipbuilding structures in general.	
*6063	Very resistant to sea water, industrial atmospheres. A superior alloy for cryogenic use (in annealed condition)	Architectural extrusions (internal and external) window frames, irrigation pipes.	E
*6061/ *6082	Heat-treatable. Medium strength alloy. Good weldability and corrosion resistance. Used for intricate profiles.	Stressed structural members, bridges, cranes, roof trusses, beer barrels	S.P.E
*6005 A	Heat-treatable. Medium strength. Good weldability and corrosion resistance.	Thin wall wide extrusions	E P.E
7020	Heat-treatable. Properties very similar to 6082. Preferable as air-quenchable, therefore has less distortion problems. Not notch-sensitive.	Armoured vehicles, military bridges, motor cycle and bicycle frames	E.P
7075	Heat-treatable. Age-hardens naturally, therefore will recover properties in heat-affected zone after welding. Susceptible to stress corrosion. Good ballistic deterrent properties. Very high strength. Heat-treatable. Non-weldable. Poor corrosion resistance.	Airframes	

* Most commonly used alloys; S = Sheet; P = Plate; E = Extrusions

Some differences in properties and characteristics for the different alloys and alloy groups can also be appreciated from F**igures 1501.03.02 till 05.**

1501.05 Aluminium Alloys ; Mechanical Properties

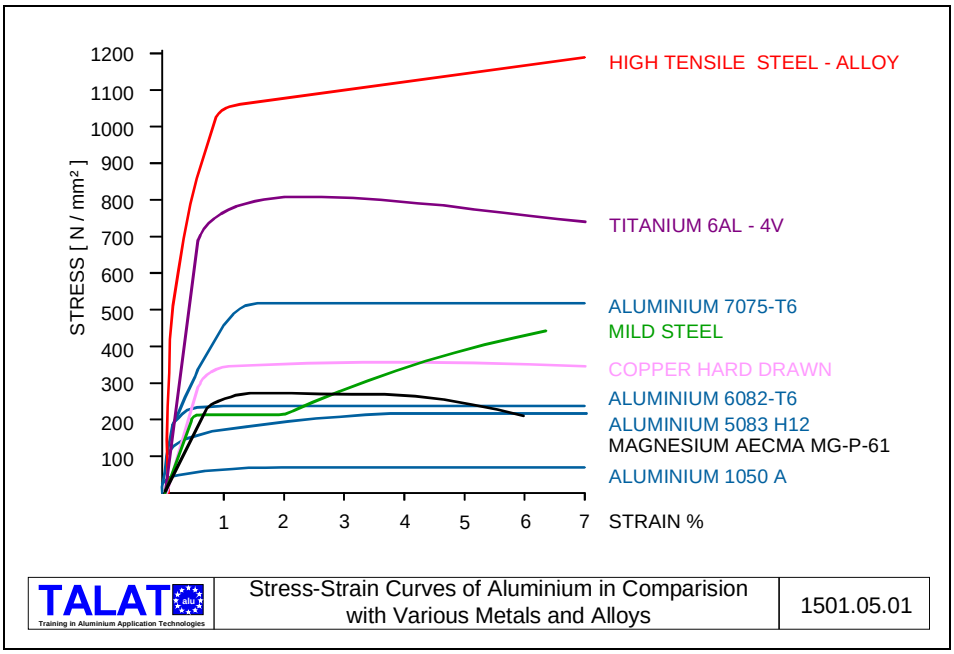
- Tensile strength
- Strength/weight ratio
- Proof stress
- Elastic properties
- Elongation
- Compression
- Bearing
- Shear
- Hardness
- Ductility
- Creep
- Properties at elevated temperatures
- Properties at low temperatures
- Impact strength
- Fracture characteristics
- Fatigue

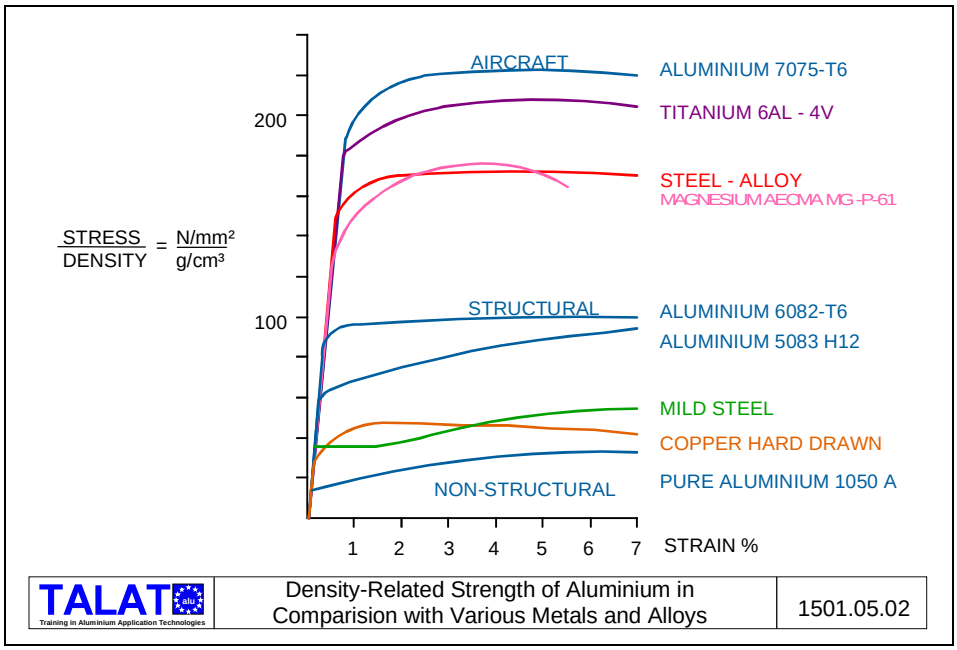
Tensile Strength

Behaviour under tension is generally considered the first yardstick of an engineering material, and Figure 1501.05.01 shows typical tensile stress/strain curves for four different aluminium alloys and compares them with a range of engineering metals. The alloys are: 99.5% pure aluminium (1050A) in the fully annealed state, suitable for deep pressing; a 4.5% magnesium-aluminium alloy (5083) after strain-hardening, by rolling, to the ″half-hard″ temper, used in marine and welded structures; a magnesium-manganese-silicon alloy 6082 after solution treatment and ageing to the fully heat treated ″T6″-condition, used in commercial structures and a zinc-magnesium-copper-aluminium alloy 7075 in the fully heat treated condition used in aircraft construction.

Strength/Weight Ratio

As can be seen from **Figure 1501.05.01** the high tensile steels have the highest strengths of all the metals. These are followed by Titanium and the aircraft aluminium alloys and some way below these the commercial structural alloys 5083-H12 and 6082-T6. If we now consider the strength available for a given mass by dividing the tensile strength by the density we get quite a different picture (**Figure 1501.05.02)**. We now find the 7075 at the top with the commercial structural alloys moving to the mid range above the common mild steel.



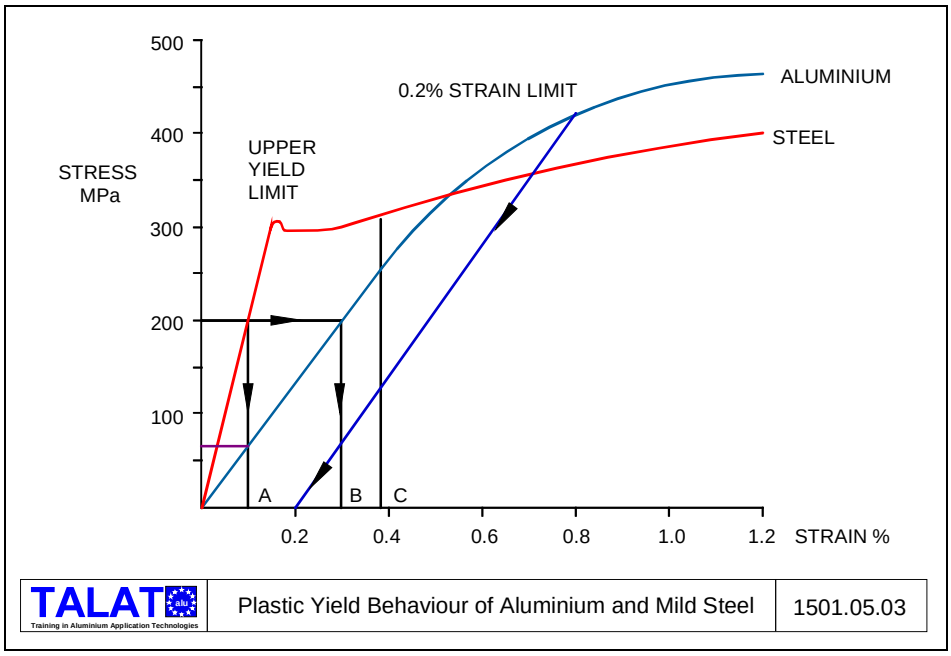


Proof Stress

With mild steel there is a clearly defined point on the stress strain curve at which the elastic limit is reached; this ″yield point″ is followed by a sharp reduction in the stress before the metal exhibits a plastic flow region with stress again increasing with strain until the ultimate stress is reached and the stress reduces to the point of failure.

In most cases no clearly defined elastic limit or yield point is to be seen on stress/strain curves for aluminium alloys, this is apparent by looking at **Figure 1501.05.03**. For this reason the point of departure from the elastic range has to be defined arbitrarily. For convenience in routine testing, a point is chosen at which the permanent deformation is easily measured: at one time, a permanent set of 0.1% of the original gauge length was used. Today, however, 0.2% is the international norm.

The stress at which a 0.2% set is observed is called the ″0.2% proof stress″ and, because it reveals the onset of plastic movement, is often of more value to the designer than the ultimate stress. **Figure 1501.05.03** shows how it is obtained from a stress/strain diagram.



Some alloys, notably the heavily strain-hardened ones, have a high ratio of proof strength to ultimate stress; in 1200 H8 for example the 0.2% proof stress is 140 MPa and the ultimate stress 150 MPa. Generally, the ratio of proof to ultimate varies from 40% for soft tempers to 95% for the hardest; in the fully heat treated alloys it is about 85%. Although a high proof stress is in itself an advantage, a high proof stress/ultimate stress ratio implies a low ductility.

Where strain is the criterion for design, it follows that the imposed stress would be one third in an aluminium member compared to one in steel. If we compare the curves for a similar strength aluminium and steel (shown in **Figure 1501.05.03)** and consider a 0.1% strain by drawing a vertical line at A the stress in the steel is 200 MPa whereas in the aluminium is only 66.6 MPa. It can also be seen from the graph that a strain of 0.3% (line B) is necessary to induce the same stress in the aluminium member. It is also worth noting that the aluminium represented by the curve in **Figure 1501.05.03** would still be

in the elastic range at 0.38% strain (line C) while the steel subjected to the same rate of strain would have entered the plastic range.

The area under the tensile stress-strain curve to the point of failure provides a measure of the capacity of a material to absorb energy under simple tensile loading.

Elastic Properties

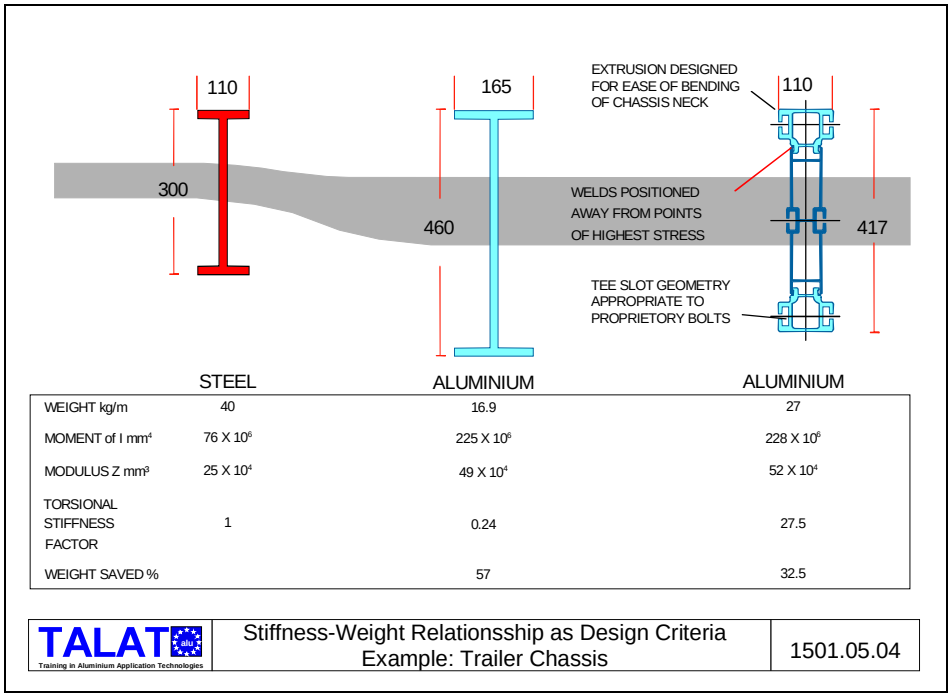
From **Figure 1501.05.03** it can be seen that for the initial part of the stress-strain curve the strain per unit increase of stress is much higher for aluminium than for steel, measurement shows that it is three times higher. The slope of this part of the curve determines the Modulus of Elasticity (Young's Modulus) e.g. stress divided by strain. It follows therefore that the Modulus of Elasticity for aluminium is one-third that of steel, being between 65500 and 72400 MPa for most aluminium alloys.

From the information already given it is clear that when a steel structural member is replaced by one of identical form in an aluminium alloy the weight will be one third but the elastic deflection will be about three times as large. From this we can deduce that an aluminium member of identical dimension to one in steel will absorb three times as much energy, but only up to the point where the stress in the aluminium remains below the limit of proportionality.

It is worth noting that stiffness is defined as the product of the Modulus of Elasticity and the Moment of Inertia of a section (E x I) and it is this which determines the deflection when subjected to a bending load. This allows the application of another attribute of aluminium, its ability to be made into a variety of complex structural shapes by extrusion. The extrusion process provides the designer with the opportunity to shape the metal to achieve maximum efficiency in the design of a section usually by making it deeper. However, making a section deeper often sacrifices some of the potential weight saving with the result that it only weighs about half that of the steel member instead of a third.

Figure 1501.05.04 shows two different approaches of saving weight when using aluminium instead of steel for the main beams of a road trailer. All sections have the **same bending stiffness**, the aluminium 'I' beam has been designed with a maximum overall extrusion dimension and minimum extrusion thickness, while the aluminium box beam has been designed to the same width as the steel beam but with additional special features to improve the build. The aluminium I beam exhibits an improved section modulus and consequently a lower induced stress in bending in addition to a 57% weight saving, but because of its slender shape has inherent poor torsional stability. The aluminium box beam exhibits an even greater improvement in section modulus combined with a considerable improvement in torsional stability but only a 33% weight saving. By changing the design any combination of characteristics inside the practical manufacturing limits can be obtained.

Young#s Modulus can vary by as much as 40% with the addition of up to 15% Manganese but for commercial alloys it only varies one or two percent and this variation is ignored in standard structural calculations.



	STEEL	ALUMINIUM	ALUMINIUM
WEIGHT kg/m	40	16.9	27
MOMENT of I mm^4	76 X 10^6	225 X 10^6	228 X 10^6
MODULUS Z mm^3	25 X 10^4	49 X 10^4	52 X 10^4
TORSIONAL STIFFNESS FACTOR	1	0.24	27.5
WEIGHT SAVED %		57	32.5

TALAT Training in Aluminium Application Technologies | Stiffness-Weight Relationsship as Design Criteria Example: Trailer Chassis | 1501.05.04

The Torsional Modulus or Modulus of Rigidity of aluminium e.g. shear stress divided by angular strain is again about a third of that for steel being 26000 MPa for aluminium compared to 82700 Mpa for steel. The same rules should therefore be applied by the designer when looking at aluminium designs in torsion as in bending.

Poisons Ratio e.g. lateral strain divided by longitudinal strain is $\nu = 0.33$.

Elongation

The amount of permanent stretch at the instant of breaking is a useful guide to the ductility of a metal, and a minimum value is usually demanded by standard specifications. It is not, however, an infallible index of workability and selection of an alloy for forming operations should never be made on this basis alone.

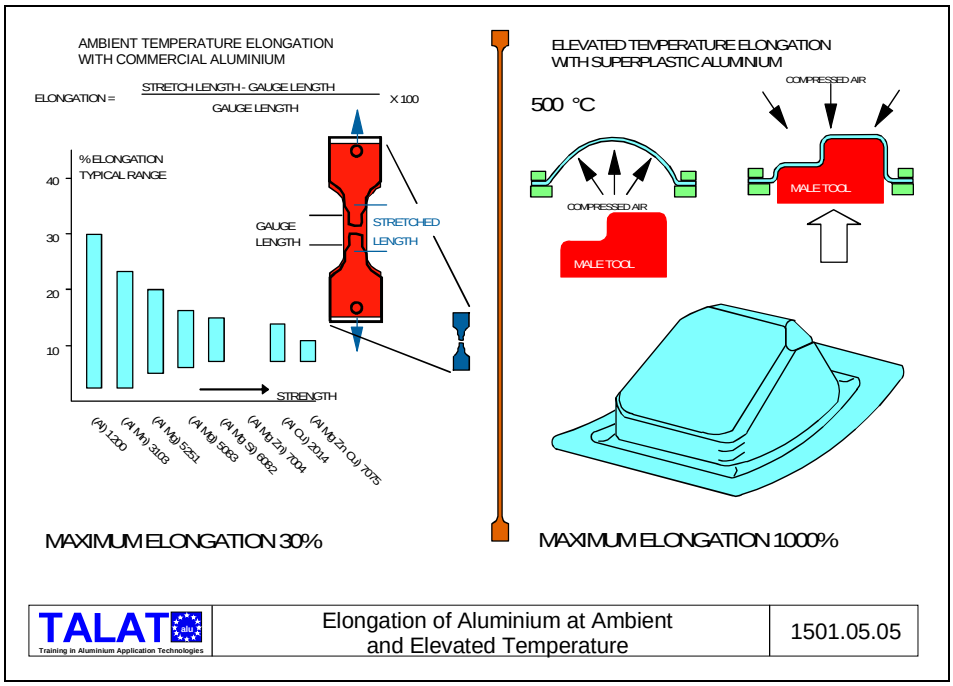
"Elongation" may be found by clamping the pieces of a broken test specimen together and measuring between marks applied before starting the test. It is generally expressed as a percentage of the original gauge length of the test specimen. Elongation is not equal everywhere in the specimen but is greatest around the fracture; the gauge length chosen will therefore greatly influence the value, and is always specified.
A gauge length of 50 mm is a common standard. For better comparison of different sized specimens, the length may be referred to the original cross-sectional area. A

gauge length of 5.65 √A (A = cross section area, equivalent to 5 diameters for round specimens) is used.

Typical elongation values for wrought aluminium alloys at ambient temperature vary from 35% (on 50mm) in annealed material to as little as 3% in fully strain-hardened metal. The heat- treated alloys possess elongations ranging from 5% to 20%. Figure **1501.05.05** shows the typical elongation range of various aluminium alloys at ambient temperature.

The elongation of most alloys increases with test temperature and this property has been extended by the development of special superplastic alloys with elongations as high as 1000% when stretched at an elevated temperature (**Figure 1501.05.05)**. Stretching metal at elevated temperatures over die forms using pressurised air is termed superplastic forming and combines the mechanical integrity of metals with the design freedom to produce complicated shapes previously only possible with plastics. In order to make the process work the material must exhibit high tensile ductility at low strain rates.

For cast alloys the elongation values can be as low as 2% and are often seen as the limiting factor in their application.



Compression

The behaviour of aluminium alloys under compressive loading does not receive the attention given to tensile properties, perhaps because the strength of structural members

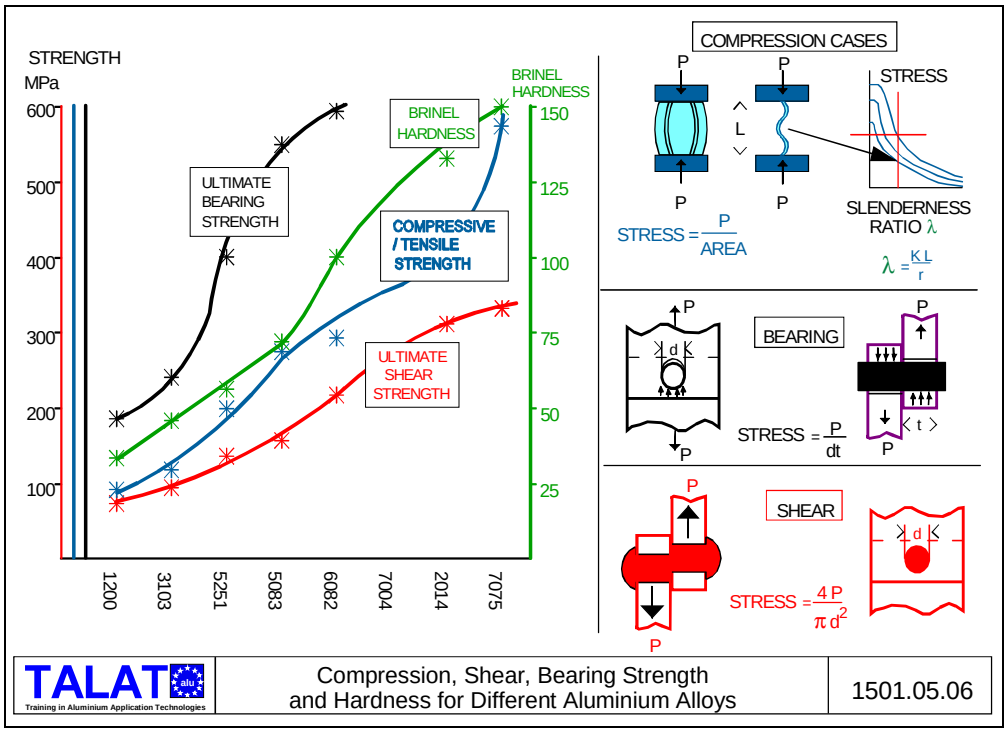
is so often limited by buckling, and the actual compressive strength of the metal is not approached (**Figure 1501.05.06).**

For most engineering purposes it is customary to use the same design stress for compressive work as for tensile. In the testing machine, an aluminium alloy will show an apparently higher strength in compression than in tension, but this can in part be attributed to the changing cross-sectional areas of the specimens, increasing in one case and decreasing in the other, while the stress is based on the original area. Cylindrical specimens of the softer aluminium alloys can be compressed to thick discs before cracking, and even then may still sustain the load. The harder alloys show a more definite failure point and pronounced cracking.

A proof stress, at which there is a small measurable departure from the elastic range, is therefore usually quoted, and will be roughly equal to the corresponding tensile proof stress; in cast or forged metal it is usually slightly higher. Sheet and extruded products, however, are often straightened by stretching, an effect of which is to lower the compressive proof stress and raise the tensile proof stress by small amounts.

Bearing

The ultimate bearing or crushing strength of aluminium is as difficult to define, test, or relate to tensile properties as it is with other metals. Bearing must, however, often be a criterion in the design of riveted or bolted structures, and a bearing yield stress is widely recognized; this is arbitrarily defined as the pressure (per unit effective bearing area) exerted by a pin at a round hole that will permanently deform the hole by 2% of its original diameter (**Figure 1501.05.06)**. This stress, for most alloys, approximates in value to the ultimate tensile stress. The ultimate bearing strength of most aluminium alloys is about 1.8 times the U.T.S.



Shear

In the wrought alloys the ratio of ultimate sheer stress to ultimate tensile stress varies with composition and method of fabrication from about 0.5 to 0.75. When test results are not available, a ratio of 0.55 is safe for most purposes (**Figure 1501.05.06).**

Rivets in low and medium strength alloys, with shear strengths up to 200 MPa can be driven cold. Small rivets in stronger alloys can be driven in the soft state immediately following solution treatment and, on natural age-hardening, shear strengths up to 260 MPa will be developed.

Hardness

Resistance to surface indentation is an approximate guide to the condition of an alloy, and is used as an inspection measure. Brinell (steel ball), Vickers (diamond) and Shore Scleroscope (diamond Hammer) testing machines are applied to aluminium alloys; typical Brinell values range from 20 for annealed commercially pure-metal to 175 for the strongest alloy (Figure 1501.05.06). Hardness readings should never be regarded as a quantitative index to tensile strength, as is often done with steels, for in aluminium the relation between these two properties is far from constant. The surface hardness of aluminium can be increased considerably by the process of hard anodising (500VPN) and is therefore often employed to improve the wear resistance of components.

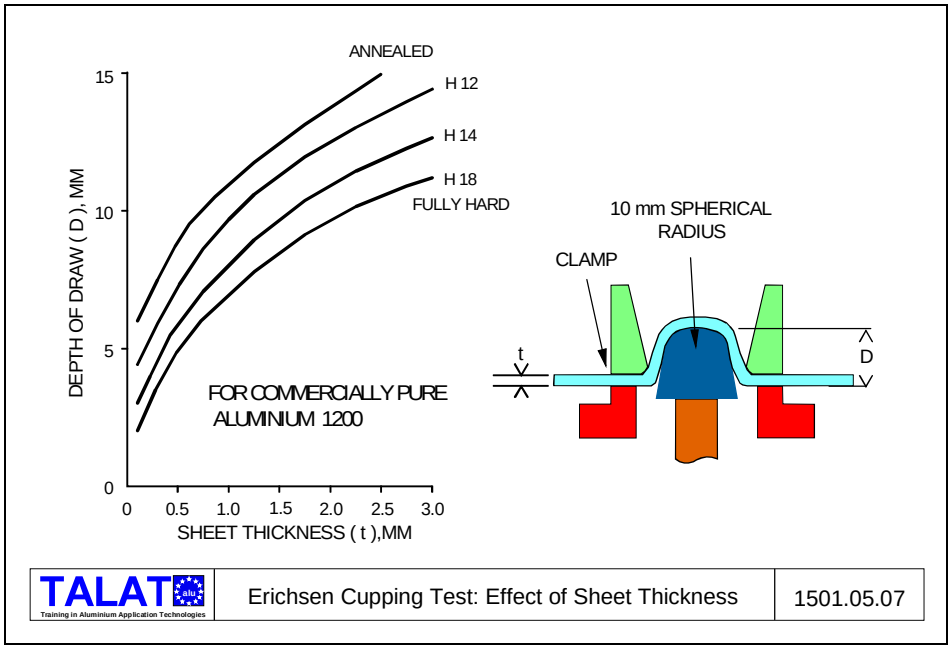
Ductility

We have said the elongation of a tensile test piece at fracture is a useful but not a conclusive key to the ductility of an alloy.

Simple bend tests are widely used as a further indication of workability. A strip of metal with smooth rounded edges is bent through 90° or 180° by hand or mallet over a steel former of prescribed radius. By using successively tighter formers, a minimum bend radius, at which there is no cracking, can be found, and is usually quoted as a multiple of sheet thickness ″t″, for example, 1½ t.

To obtain a measure of ductility a sample of sheet that is intended for deep drawing or pressing is often subjected to the Erichsen cupping test in which a hemispherical punch is forced by a hand-operated screw against one side of the sheet, stretching the metal into a dome or cup (**Figure 1501.05.07)**. The depth of penetration at fracture gives an indication of the amenability of the metal to deep drawing processes involving stretching, though not necessarily to other pressing operations.

Much of the value of this test lies in its ability to show up to two phenomena that will prevent successful drawing: a coarse grain structure produces roughness of the cup surface and perhaps an early failure through local thinning; and directionality or variation of properties in relation to the direction of rolling affects the shape of the fracture, which should be circular.

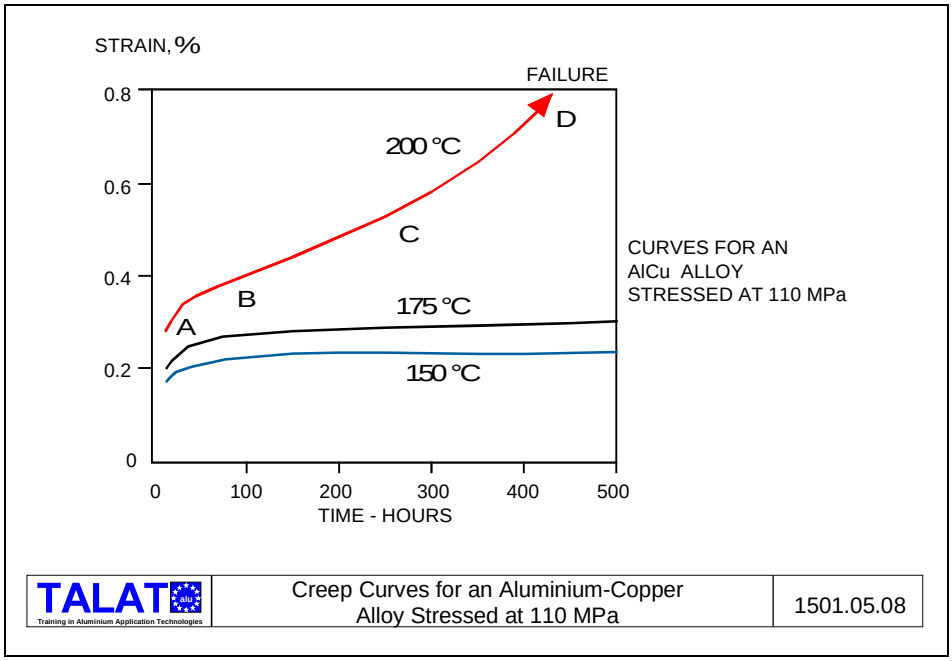


Creep

In the preceding discussions of tensile, compressive and shear properties it is implied that the stress is **increased continuously** and that the accompanying strains are independent of time under any given stress. If, however, a stress less than the ultimate strength is **constantly maintained** for a long period of time, the strain increases continuously (**Figure 1501.05.08)**. If the stress is high enough or held long enough, the specimen eventually fails in the mode which would have occurred under continuously increasing loading. In this respect, the behaviour of aluminium is like that of other metals, and the term used for this form of failure is Creep Rupture.

The creep strength of metals reduces as the operating temperature increases, again aluminium's behaviour is the same as other metals. It follows, therefore, that Creep strength cannot be expressed by a single number but must be related to operating temperatures, time and amount of deformation. **Figure 1501.05.08** illustrates these relationships for an Al-Cu alloy.

These data are important to the designer of a structure which is subject to stress and temperature, such as hot tarmac carrying vehicles (required life 1000's hrs), some forms of pressure vessels used in process plant (required life 100,000 hrs). It may also be necessary for predicting the life of a structure in hazard situations such as a safety critical structure surrounded by a fire (30 mins), or even a very short rupture life as maybe required in a rocket shell (2 mins). In all of these cases the time to **failure** at a given stress level and temperature is the design criterion, and the data are usually applied with a suitable safety allowance on time.



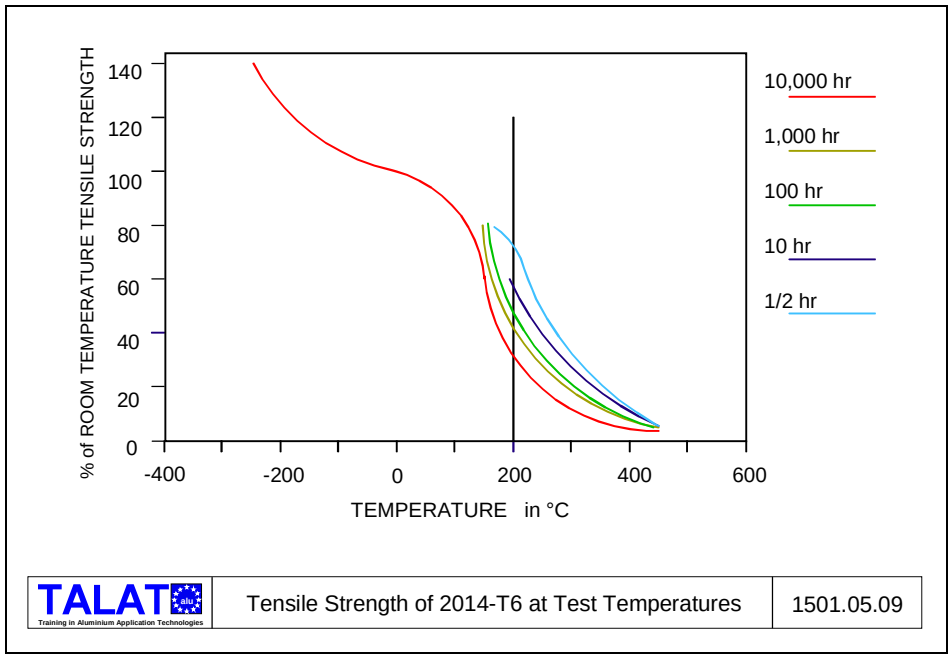
The information available to the designer is generally the result of tests on tensile specimens subjected to constant stress at a carefully controlled temperature. By loading a number of specimens at different stress levels and constant temperature, or at different temperatures and a constant stress, perhaps for some thousands of hours, a family of curves can be obtained of the form shown in the graph **Figure 1501.05.08**. In each of these curves, deformation increases in four stages: first elastically, on loading (O to A on the top curve); secondly (A to B), at a decreasing rate; thirdly (B to C), at an almost constant rate, which may be negligibly small at low stresses and temperatures; and lastly (C to D), at an increasing rate which leads to failure. In this example, only the top curve has entered the final stage. The graph indicates the ways open to the designer to interpret the data. One route is to limit the total creep at a given temperature to say 0.1% in 10,000 hrs resulting in an allowable working stress. Another is to limit the working stress to a level at which the final stage of the creep curve will not be entered during the intended life of the product, and at which the total deformation at the end of this time will be within acceptable limits. Either of these methods can be applied to proposed applications.

The time taken to produce creep data can be very protracted and it is usually considered impractical to continue creep and creep rupture tests beyond a few thousand hours. However, designers of pressure vessels require data that will indicate rupture at 100,000 hrs and it is therefore necessary to extrapolate the available data. Several methods have been devised for making such extrapolations, notably those by Larson and Miller, White, Clark and Wilson, Manson and Haferd and Orr, Sherby and Dorn.

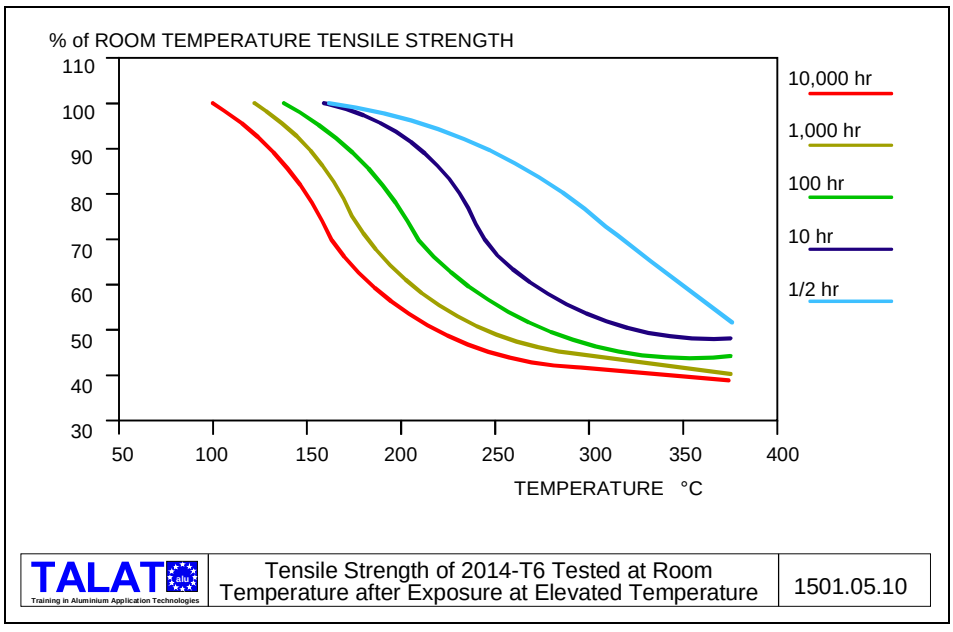
Properties at Elevated Temperatures

The strength of aluminium alloys decreases with the increase in temperature excluding the effects of age-hardening within narrow temperature ranges for various holding periods. The time of exposure is important in the case of cold worked or heat-treated alloys (**Figure 1501.05.09)** but has little or no effect on the properties of annealed alloys. The heating time at test temperature is often quoted as 10,000 hrs, but with the time-temperature dependence of strength it may be necessary for other exposure times to be considered.

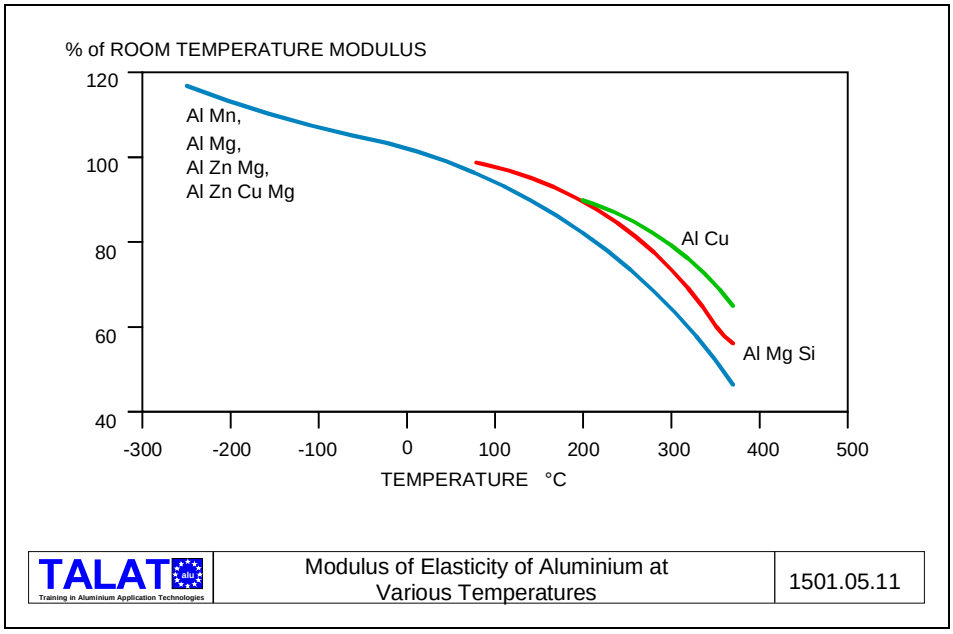
Shear, compression, bearing and fatigue strengths vary with temperature in much the same way as tensile strength; ratios of these strengths to tensile strength may be taken as constant.



The reduction in strength caused by exposure to elevated temperatures can only be regained by heat treatment or cold work or a combination of these processes which is usually impractical in the case of fabricated items. The tensile strength of an AlCu4MgSi alloy, tested at room temperature after exposure at elevated temperature, is shown in **Figure 1501.05.10**. After either short term exposure at high temperature or long term exposure at medium temperature the material approaches a super soft annealed condition and the lower limit strength becomes constant.



The modulus of elasticity of aluminium alloys also decreases as the operating temperature increases but unlike strengths which stabilise at a lower annealed value, the modulus of elasticity returns to its room temperature value after exposure (**Figure 1501.05.11)**.



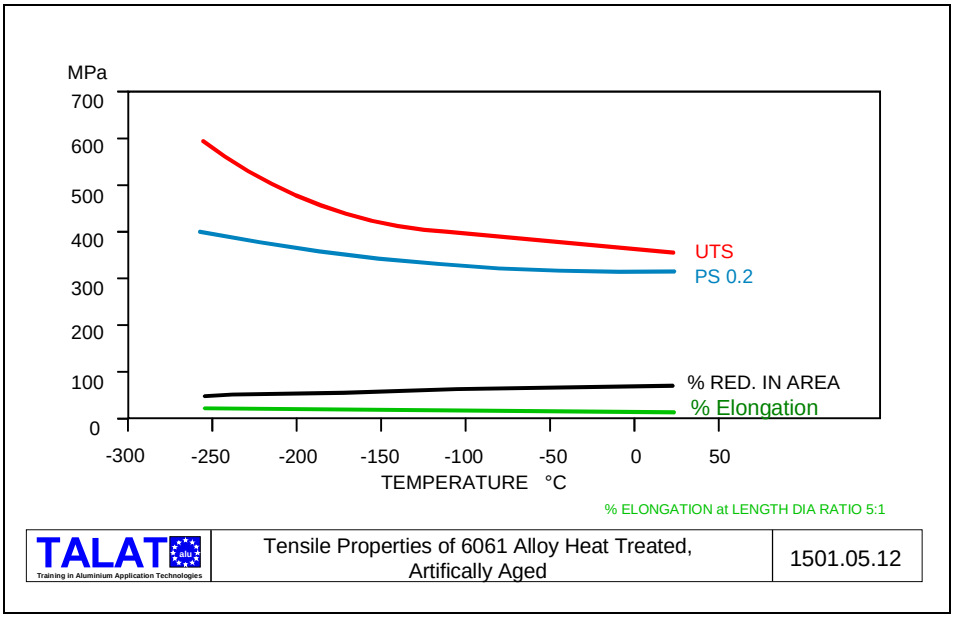
Properties at Low Temperatures

Aluminium and its alloys have no ductile to brittle transition at low temperatures, indeed, their strengths increase with decreasingtemperature. The strengths of stable temper aluminium alloys are not influenced by the time of exposure at low temperatures neither are the strengths at room temperature after exposure at low temperature.However, freshly solution treated heat treatable alloys can be held in this condition for long periods by storing them at a low temperature because of the retardation of the ageing process. This is used to good effect when placing aircraft rivets of the AlCuMgSi type which may be solution treated prior to use by heating to 495^0C for a period of time between 5 and 60 minutes, depending upon the size and quantity of rivets being processed, after which they are quenched in cold water. The rivets remain soft after quenching for up to two hours at ambient, but at minus 5^0C this is extended to forty-five hours and at minus 15^0C to one hundred and fifty hours.

The increase in strength of aluminium alloys at low temperatures is negligible down to minus 50^0C but begins to increase significantly below minus 100^0C **(Figure 1501.05.12).** The elongations of most aluminium alloys also increase with the reduction in temperature down to minus 196°C whereupon some alloys notably with higher

magnesium content (4.5% and above) begin to reduce again but not below the ambient figure.

Shear, compression and bearing strengths - all improve at low temperatures, also the moduli of elasticity under tensile, compressive and shear loading are 12% higher at minus 196^0C than at room temperature.



Impact Strength

As already indicated the low elastic modulus of aluminium alloys is an asset when a structure is subjected to shock-loading conditions: an aluminium alloy member will absorb three times as much energy before permanent damage occurs than a steel member of equal moment of inertia and strength.

Energy absorption figures from tests or notched specimens in Izod or Charpy pendulum machines are, as with other metals, not directly applicable to design work. Again, the results from different alloys of aluminium are so varied and so unrelated to performance under structural conditions, that this type of test is little used.

Fracture Characteristics

By this we mean a materials tendency to exhibit rapid propagation of a crack without appreciable plastic deformation. Information on this form of failure is vital for the design of structures working at stress levels and containing high elastic energies where

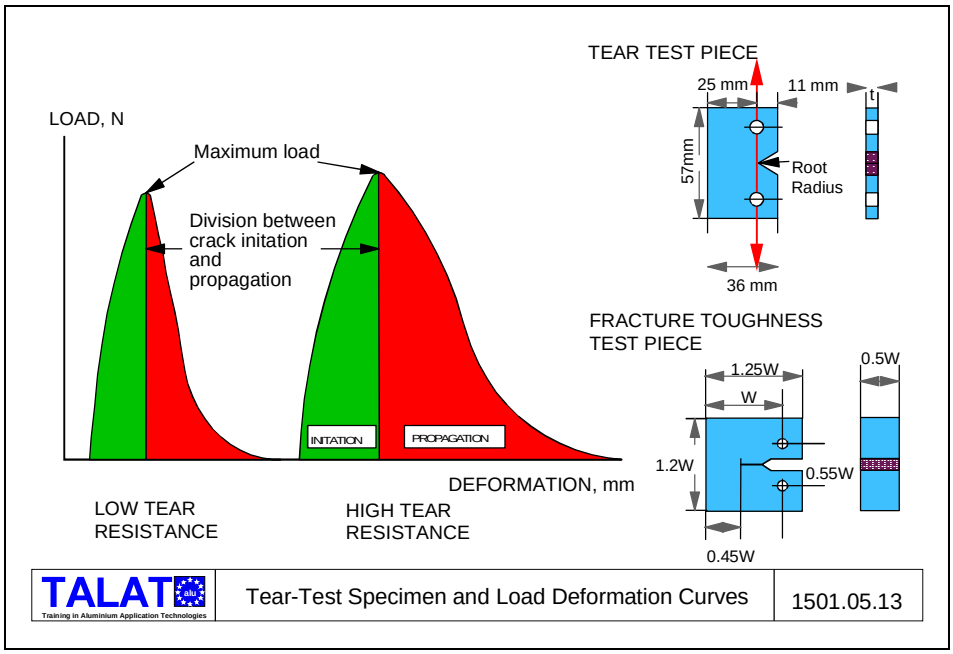
sudden failure would be catastrophic. Elongation and reduction of area from tensile tests and the ratio of yield to tensile strength, both give indications of fracture characteristics, but for the engineer these indications are seldom sufficient to be used alone as a basis for design.

Charpy and Izod notched bar impact tests have been widely employed to determine the transition temperatures for ferritic steels, i.e. temperatures at which the alloys begin to exhibit brittle fracture characteristics, but these tests are generally unsuitable for aluminium and its alloys because the latter do not exhibit a transition temperature. Also notched bar impact test values for aluminium alloys are almost constant from ambient down to temperatures of minus 268^0C; in addition most wrought alloys are so tough the test bars do not fracture. Therefore no useful data are obtained.

To overcome this problem an adaption of the Navy tear test, originally developed by Noah Kahn to investigate the sudden failures of welded steel ships, is often employed to assess a fracture rating factor for aluminium and its alloys. In this test the energies required to initiate and propagate a crack in a specially prepared test piece (**Figure 1501.05.13)** are obtained by calculating the appropriate areas under the load extension curve. The energy required to propagate a crack in the tear test divided by the net cross sectional area of the specimen is referred to as the "unit propagation energy". It provides a measure of tear resistance and, indirectly, a measure of fracture toughness.

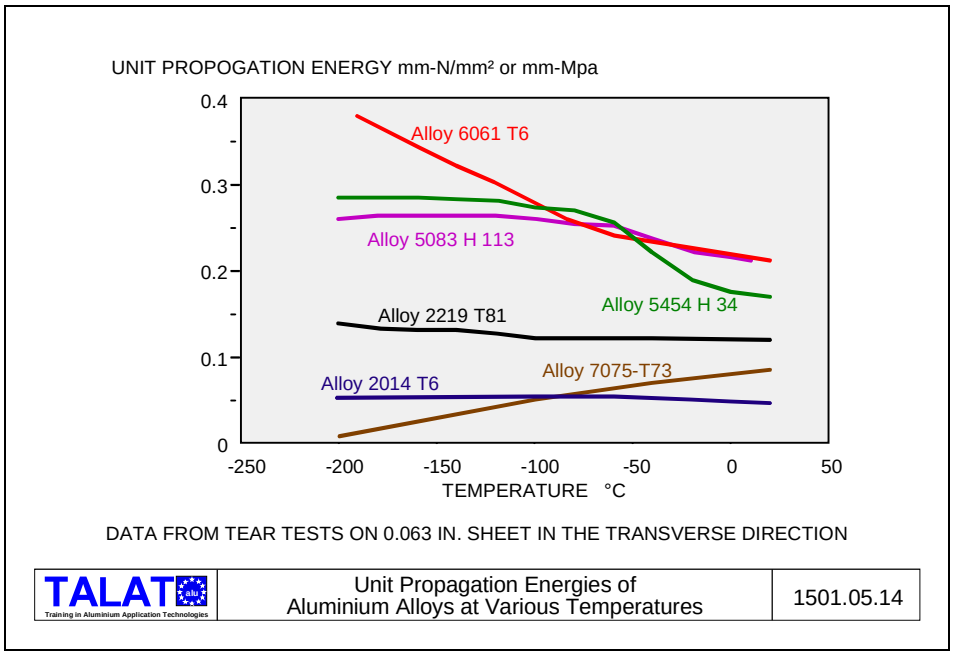
The unit propagation energy obtained from the test can be related directly to the strain energy release rate for alloys that conform to the fracture mechanics theory, thereby providing a realistic measure of the resistance to rapid crack propagation.

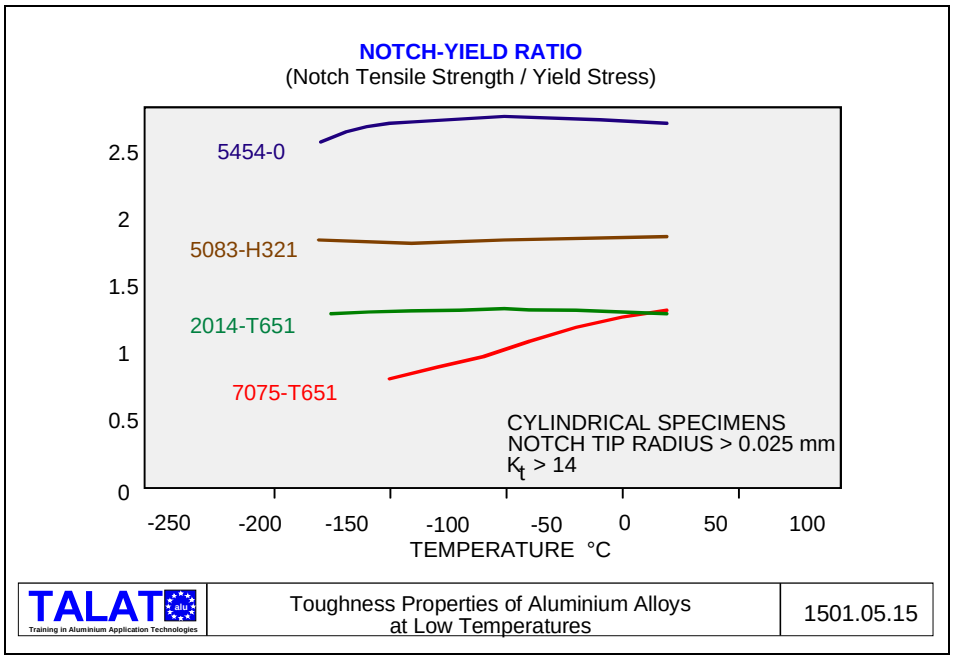
Test procedures have also been developed which relate the fracture strength of a material to a flaw or crack size or specific design detail, thereby providing a measure of "fracture toughness". Fracture toughness can be described as the resistance of a material to unstable crack propagation at elastic stresses, or to low ductility fracture of any kind. Testing for fracture toughness requires the initiation of a crack of known length in a specially prepared test piece either by fatigue loading but usually by cutting a very thin slot followed by loading in the same manner as the Navy tear test (**Figure 1501.05.13),**. A relationship between the stress intensity factor K, uniform gross tensile stress σ_a, and the length of the crack 2a is given by $K = \sigma_a \sqrt{2\pi a}$. The stress intensity factor K (at the onset of unstable crack propagation) decreases with the increase in metal thickness and approaches a constant minimum value which is identified as K_{Ic} the "critical elastic stress intensity factor".or the plain strain fracture toughness. K_{Ic} is analogous to yield stress since it is the minimum stress intensity at which failure can start at a given temperature and at full thickness for plain strain conditions. The fracture toughness route is not suitable for highly ductile alloys since they do not exhibit rapid crack propagation under elastic conditions. The test is therefore usually confined to the high strength heat treatable alloys.



The ability to resist the growth of cracks remains high for most aluminium alloys even at very low temperatures and in the case of 6061 T6 increases considerably (**Figure 1501.05.14)**. For most aluminium alloys the ability to deform plastically and resist crack growth is so great that unstable crack growth in elastically stressed material (brittle fracture) is impossible.

A convenient way to present the toughness of an alloy is by expressing it in terms of notch toughness as measured by the notch-yield ratio, which is the notch tensile strength divided by the tensile proof strength. The notch toughness of most aluminium alloys remains constant even at cryogenic temperatures (**Figure 1501.05.15)**, the exceptions being the high strength 7000 series alloys as indicated by 7075 on the graph.





Fatigue

(see also **TALAT Lectures 2400**)

In common with other metals aluminium will fracture when subjected to variable or repeated loads at stress levels considerably lower than it would be the case with static loads. This type of failure which consists of the formation of cracks under the action of the fluctuating loads is known as fatigue. The fluctuating loads in practice could be caused by live loads, vibration or repeated temperature changes. The direction in which

the fatigue crack propagates is always perpendicular to the line of action of the stresses causing the crack. As the crack progresses the stress on the residual cross section increases so that there is a corresponding increase in the rate of crack propagation. Ultimately a stage is reached when the remaining area is insufficient to support the applied load and final rupture occurs. Fatigue cracks may be very difficult to detect since unlike tensile failures there is no visible surface contraction at the point of failure.

When assessing fatigue three basic factors need to be known:

1. Number of stress cycles.
2. A definition of the stress cycle.
3. Surface finish or contour shape of the component.

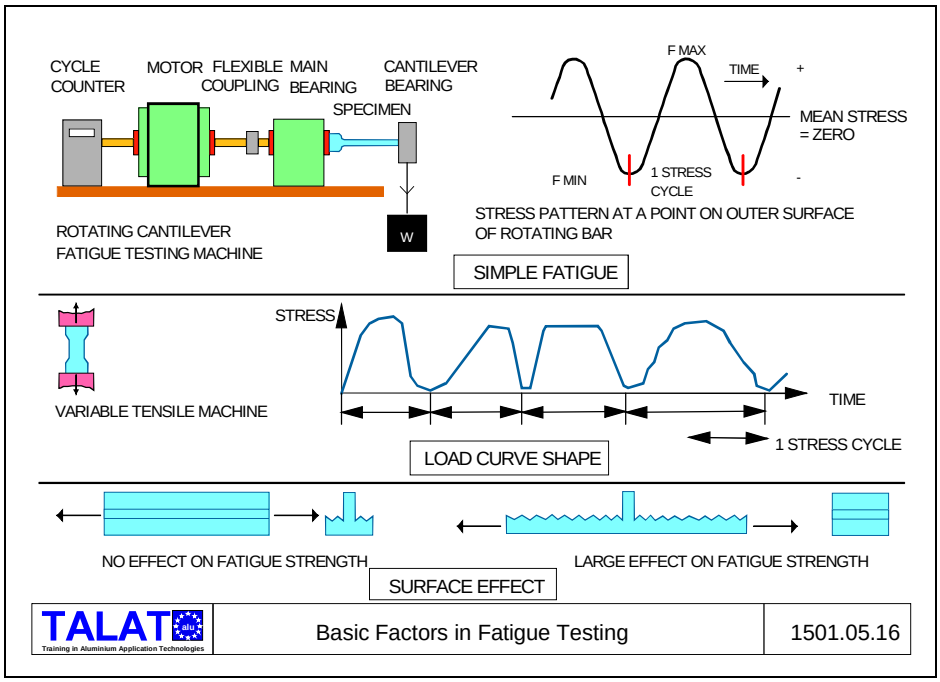
The number of stress cycles is usually known or can be established by the designer for a given application.

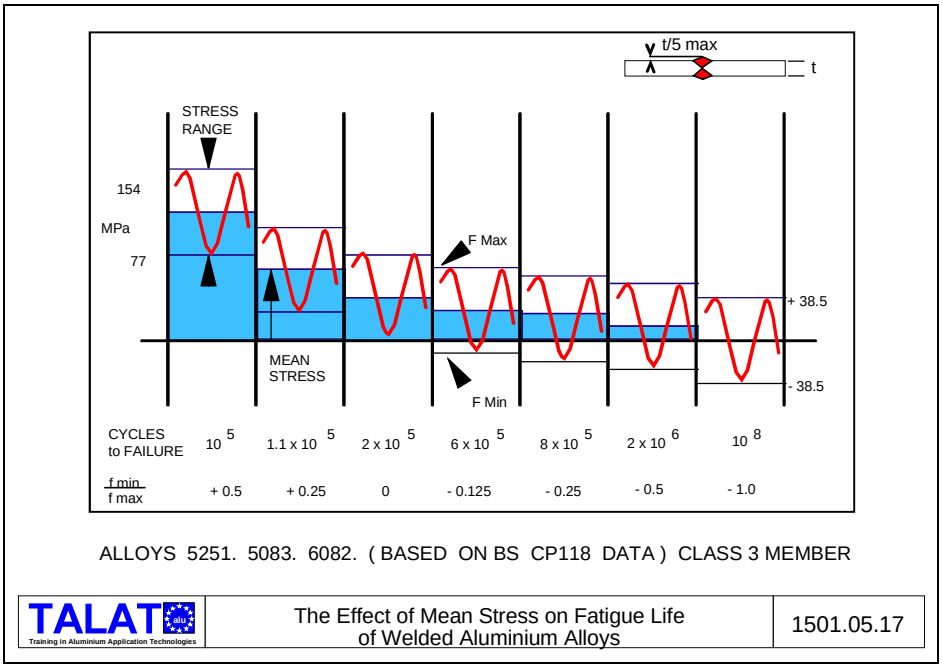
When defining a stress cycle there are four basic parameters;

1. The minimum stress S_{min}
2. The maximum stress S_{max}
3. The mean stress $S_m = (S_{min} + S_{max})/2$
4. The stress range $S_r = S_{max} - S_{min}$

The stress cycle is fully defined provided that any two of these four quantities are known. **Figure 1501.05.16** shows these factors relating to typical stress cycle patterns. Machines have been developed to apply these various types of loading rapidly and easily. A simple and well known example is the Wöhler machine, in which a cylindrical specimen is arranged as a beam or a cantilever under a steady load. Rotation of the specimen subjects it to sinusoidal alternating loading cycles. The AMSLER test machine has been developed to provide high speed tensile and compression loading of specimens to a specified wave form.

The effect of the mean stress or superimposed stress on the stress cycle is shown in **Figure 1501.05.17**. As can be seen an imposed tensile stress reduces the number of cycles to cause failure while an imposed compressive stress increases the cycles.

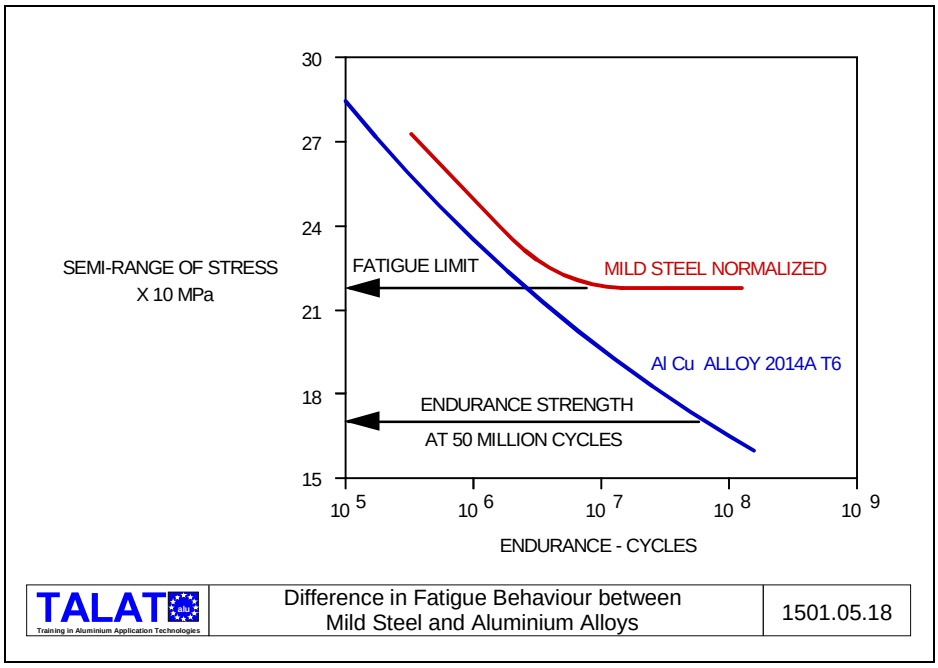




Unlike creep testing, fatigue testing can be speeded up; the results are not prejudiced until frequencies of the order of 500 Hz are approached. This enables many millions of cycles to be applied in a practical time. Loads applied at resonant frequency, mechanically or electrically excited can often be used to save power.

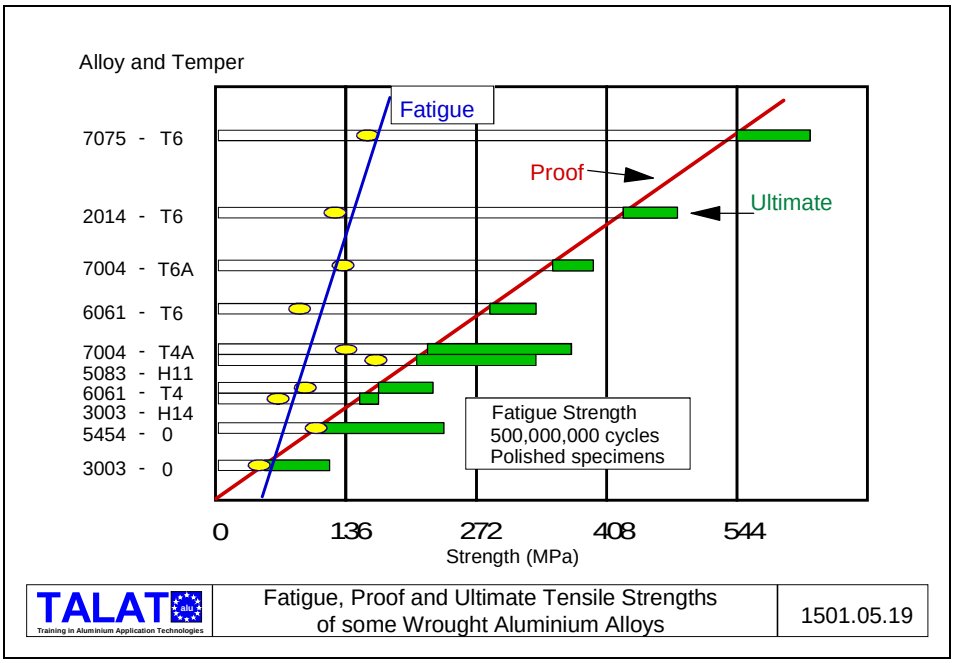
The usual procedure in fatigue testing is to test a number of specimens at different stress levels. By plotting, in each case, the stress to cause failure, a stress/number (S/N) curve is obtained of the type shown in **Figure 1501.05.18**. It will be seen that the S/N curve for steel flattens out eventually, implying that there is a level of stress below which the

material will never fail. This stress is its ″fatigue limit″. Most aluminium alloys, like other non-ferrous metals do not show this limit, (exceptions are provided by the aluminium magnesium 5000 series alloys) so it is necessary to quote the maximum stress permissible for a specified life: 50 million cycles is a widely used figure for aluminium alloys.



The fatigue, proof and tensile strengths of a number of aluminium alloys are shown plotted and compared in **Figure 1501.05.19**. The fatigue strengths were determined from rotating-beam tests at five hundred million cycles using polished specimens.

The fatigue resistance will be considerably reduced by local stress raisers such as sharp grooves, shoulders abrupt changes in profile or even machining marks and scratches. This is particularly the case when the surface imperfection or stress raisers run across the direction of the stress field. These details produce small zones of intensified stress which have a far greater influence on the fatigue strength than the differences which can be attributed to the application of different alloys. Design and manufacture are therefore always the key elements in influencing the fatigue resistance of a component or structure.



These last statements are particularly true when considering welded fabrications and they hold true both for aluminium and steel. There are three major factors responsible for the low fatigue strength of welded joints.

Profile:

A weld produces a surface discontinuity, which creates stress concentrations. It follows therefore that a fillet weld will have a lower fatigue strength than say a flush ground butt. The orientation of the surface discontinuity is also important (as illustrated in **Figure 1501.05.16).**

Defects:

Welds often contain surface ripples or crack-like discontinuities which act as fatigue crack initiators.

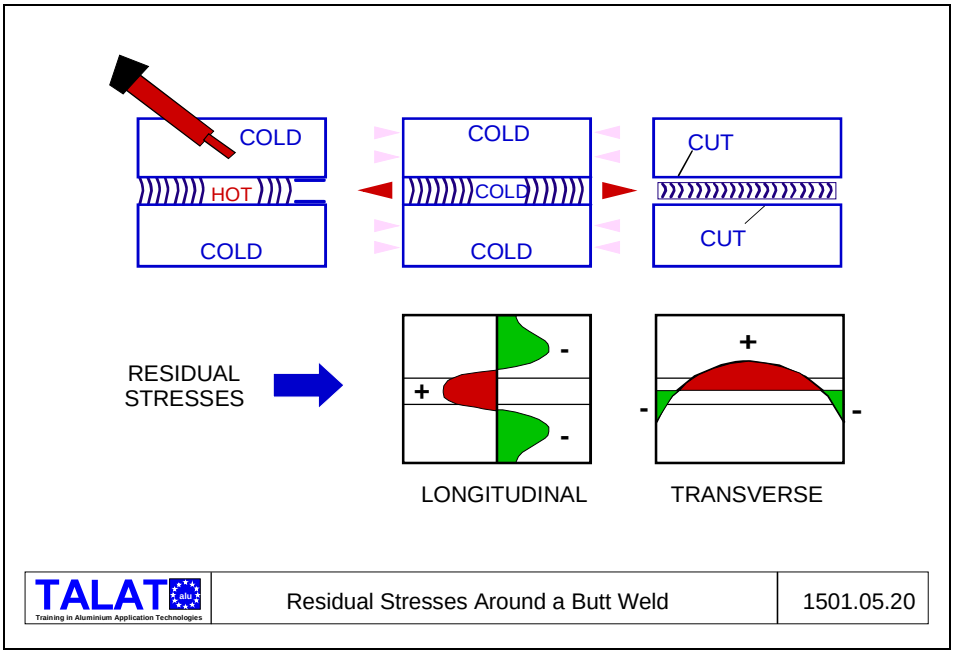
Residual stress:

Welded joints contain high levels of tensile residual stress (**Figure 1501.05.20),** which act like the superimposed stress shown in **Figure 1501.05.17**. These are caused by the thermal shrinkage inherent in the process.

The presence of residual welding stresses and the possibility of stress raisers introduced to the parent material during its working life by the accumulation of cuts and scratches, has prompted recent actions to rationalize the application of fatigue data in commercial structures. This latest thinking is applied to the S/N curves published in **The British Standard for the structural use of aluminium** (BS 8118, Part1:1991). These curves assume that a maximum stress of yield tension is always present in the joint. From a practical standpoint this therefore assumes that the life of a joint subjected to a stress fluctuation between -30 MPa and + 40 MPa is not different from that of the same joint subjected to a stress fluctuating between +30 MPa and +100 MPa. The curves only force

the designer to assess the stress range and ignore any further influence of mean stress; this follows the same format as that used in the UK structural steel bridge design code BS5400. The aluminium values for the S/N curves in BS 8118 are nominally BS5400 steel divided by 3. Other countries are applying the basic fatigue data in different ways in practice, for instance Canada still uses the concept of applied mean stress. Therefore the interpretation of theory into practice will continue to be a point of inconsistency for the foreseeable future.

The high levels of tensile residual stress at the welds can be reduced by hammer or shot peening which has the effect of inducing beneficial compressive stresses and thereby improving the fatigue life. The fatigue life of the weld can also be improved by removing weld surface ripples by grinding or water jet erosion.



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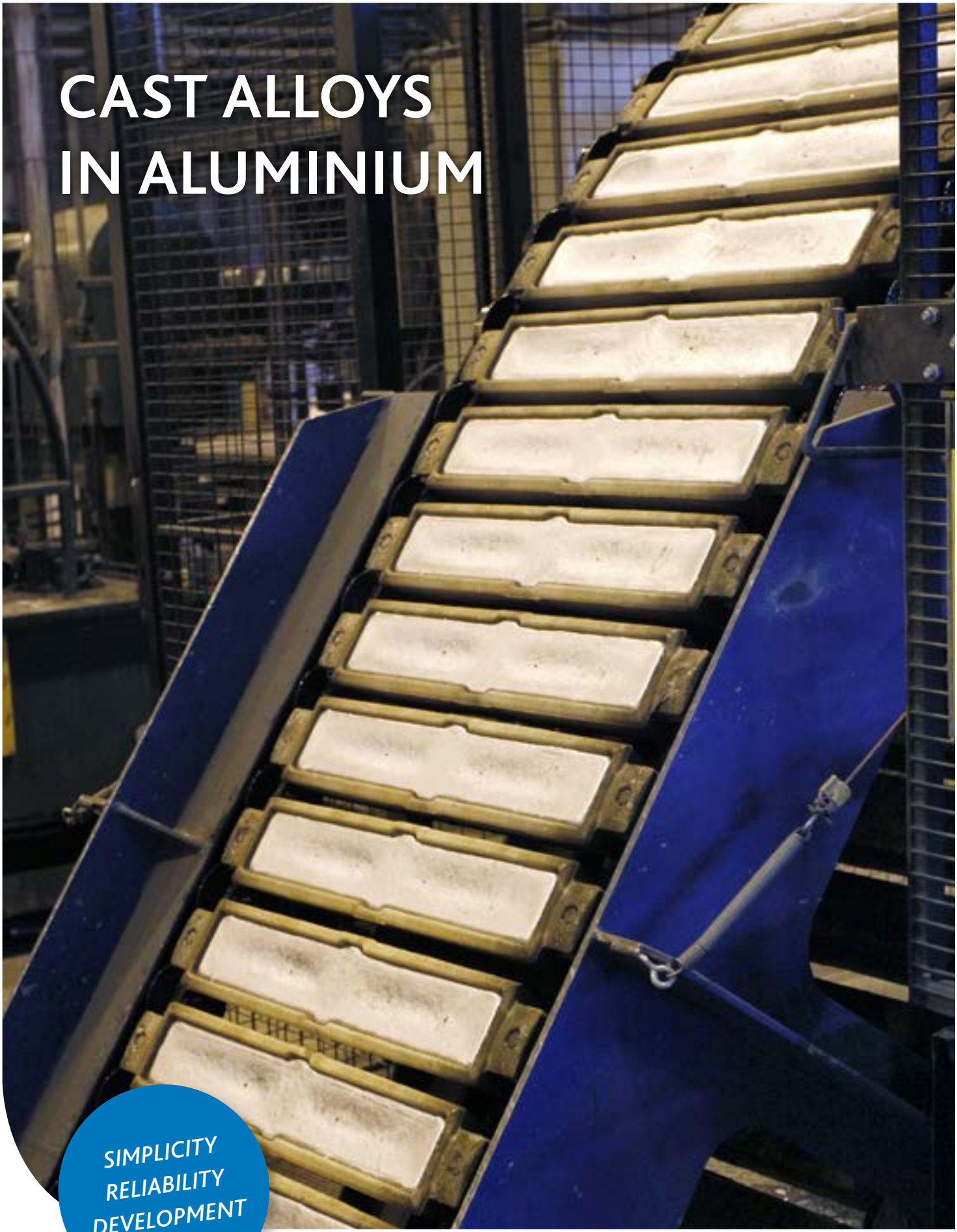
CAST ALLOYS IN ALUMINIUM



SIMPLICITY
RELIABILITY
DEVELOPMENT

STENA ALUMINIUM

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CUSTOMER-SPECIFIC ALLOYS.

This brochure presents the European standard for aluminium alloys for foundry use. At Stena Aluminium, however, the majority of the alloys we produce are to specific customer requirements. Our alloys are used particularly in the automotive, electronics, engineering and furniture industries. Today, we produce around 450 customized aluminium alloys with varying properties in terms of conductivity, thermal conductivity, corrosion resistance, strength, polishability, breaking strength, yield strength, machinability, weldability and so on.

UNIFORM HIGH QUALITY

We guarantee uniform high quality and deliveries within the set specifications. Our process guarantees uniform quality. With extensive quality controls, from the arrival of raw materials throughout the process up to final inspection on delivery, uniform quality according to the specification requested by the customer is guaranteed.

As our customer, you can always be sure we are delivering the right quality so you in turn can deliver high quality parts to your customers.

INGOTS OR LIQUID

Stena Aluminium was the first in the Nordic countries to deliver liquid aluminium to industry, in large specially built thermoses that hold up to eight metric tonnes of liquid aluminium per container. The molten aluminium has the appropriate temperature and can be used directly in the customer's process.

OUR EFFORTS TO MEET TOMORROW'S NEEDS

Our task is to help our customers to be more successful. We do this by creating long-term relations that are based on flexibility, the right quality, precise delivery, and high availability of products and technical support.

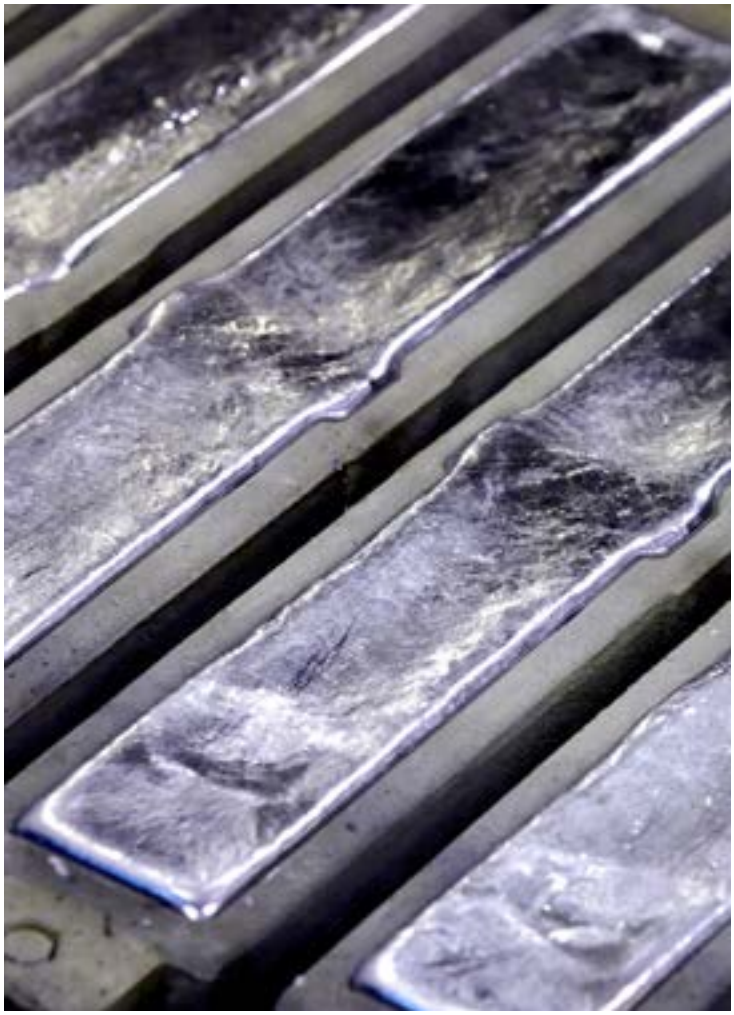
In order to help our customers succeed, Stena Aluminium works continuously to find new ways to make improvements. We are also constantly developing our processes and we are at the cutting edge in terms of customized product development.

Our operations are certified in accordance with ISO 9001 and ISO 14001, and the work environment is certified according to AFS 2001. The systems are an active part of our daily work.

ALUMINIUM ALLOYS FOR YOUR PARTICULAR NEEDS

Stena Aluminium is Scandinavia's leading producer of aluminium through recycling. The foundation for our business is the manufacturing and marketing of customized aluminium alloys to foundries as well as alloying elements to steelmills. Our production takes place in Älmhult, in Sweden. The current licensed volume amounts to 90,000 metric tonnes per year.

We are part of the Stena Metall Group, which runs operations at more than 250 facilities in 13 countries. Among other things, this guarantees good availability of raw materials of the right quality.




STENA ALUMINIUM

2

CONTINUOUS DEVELOPMENT OF CUSTOMER BENEFIT.

Stena Aluminium is constantly pursuing its development work so it can offer market leading products and service. The success of recent years is spurring us on to make even greater efforts, which benefits you as our customer.

TECHNICAL SUPPORT & TRAINING

Stena Aluminium provides technical support in process and product development for increased quality and efficiency. This can concern everything from optimization of product properties to the smelting and casting process. We also perform many types of material analysis, such as chemical analysis, microscopy, and strength tests. In addition, we provide our customers with advice, support, and training during customer events.

We also provide training, for example, in metallurgy, quality, design, and process. These are adapted to suit you as our customer and they are based on the participants' existing knowledge. Some examples of the subjects covered:

- Quality influences in the casting process
- Metallurgical overview
- Aluminium alloys
- Design in aluminium
- Aluminium and the environment

The courses can be held on the customer's premises or at Stena Aluminium.

INCREASED PRODUCTION WITH LESS ENVIRONMENTAL IMPACT

During recent years, we have invested almost SEK 200 million in new production and environmental technology. With advanced flue-gas treatment, afterburner chambers and a new smokestack, we can produce significantly more for you while still reducing our environmental impact compared to previously.

CUSTOMER AND ENVIRONMENTAL BENEFIT HAND IN HAND

In recent years, we have made a number of investments that have created ripples in our surroundings. We are alone in the Nordic countries in being able to deliver liquid aluminium. This solution creates major benefits for our customers and the environment. Using this solution, our customers can take delivery of liquid aluminium directly into their production process, which simplifies the customer's process and saves energy. Each fully loaded rig with liquid aluminium saves around two metric tonnes of carbon dioxide emissions.

Another example is the large quantities of waste heat from our production process, which is being made use of and distributed as environmentally-smart district heating in Älmhult; this is equivalent to heating around 1200 houses/year.

During recent years, we have been awarded several distinctions for our development work: we were chosen as the Metal Recycler of the Year in Sweden; awarded Älmhult's Development prize together with the E-Prize, the latter a prize presented by Veckans Affärer and E.ON for smart energy solutions that unite innovation, the environment, and good business.

It is pleasing that the world is paying attention to our efforts, and the awards are spurring us on to be even better.

LEADING RESEARCH PROGRAM

Stena Aluminium is part of the Stena Metall Group, which runs a leading research program within the area of recycling. In 2007, we initiated a globally unique professorial chair in material recycling at Chalmers University of Technology in Gothenburg.

Several of the projects concern the development of new aluminium alloys as well as new solutions for reducing the quantity of waste and handling residue products from production. In parallel, we are also running development projects jointly with customers, suppliers, trade associations, universities and colleges to strengthen the entire production and logistics chain.

OUR COLLABORATION IS CREATING MAJOR ENVIRONMENTAL BENEFIT.

The collaboration with the Stena Metall Group's recycling companies is important for Stena Aluminium's supply of large volumes of quality raw materials. As our customer, you are involved in creating major environmental benefit. By recycling aluminium, we are saving 95% of the total energy used compared to producing new aluminium from bauxite.

Every year, our production contributes to preventing carbon dioxide emissions of 550,000 metric tonnes per year at the production rate at the time of writing. Emissions would have risen by this much if nothing was recycled while the same quantity of aluminium was produced from completely new raw materials from the Earth's crust. The benefit is equivalent to the environmental impact caused by heating 1.2 million Swedish homes, so recycling is creating major environmental benefit.

Thank you for your collaboration!

3 DIE CASTING ALLOYS.

We present here the European standards for die casting. We show the chemical requirements for composition, casting properties, heat treatment, and mechanical properties. We also provide a description of the general properties as well as the possible areas of use. These are, of course, available in our product range, but if you wish we would be happy to help you produce the right alloy for your particular need.

Alloys for die casting EN 1676		Chemical composition for casting alloys EN 1676 (in weight %)											
Alloy designations: Numeric	Chemical formula	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Pb	Sn	Ti [1]	
EN AB-43400	Al Si10Mg(Fe)	9.0-11.0	0.45-0.9 (1.0)	0.08 (0.10)	0.55	0.25-0.50 (0.20-0.50)	-	0.15	0.15	0.15	0.05	0.15 (0.20)	
EN AB-44300	Al Si12(Fe)(a)	10.5-13.5	0.45-0.9 (1.0)	0.08 (0.10)	0.55	-	-	-	0.15	-	-	0.15	
EN AB-44400	Al Si9	8.0-11.0	0.55 (0.65)	0.08 (0.10)	0.50	0.10	-	0.05	0.15	0.05	0.05	0.15	
EN AB-44500	Al Si12(Fe)(b)	10.5-13.5	0.45-0.90 (1.0)	0.18 (0.20)	0.55	0.40	-	-	0.30	-	-	0.15	
EN AB-46000	AlSi9Cu3(Fe)	8.0-11.0	0.6-1.1 (1.3)	2.0-4.0	0.55	0.15-0.55 (0.05-0.55)	0.15	0.55	1.2	0.35	0.15	0.20 (0.25)	
EN AB-46100	Al Si11Cu2(Fe)	10.0-12.0	0.45-1.0 (1.1)	1.5-2.5	0.55	0.30	0.15	0.45	1.7	0.25	0.15	0.20 (0.25)	
EN AB-46500	Al Si9Cu3(Fe)(Zn)	8.0-11.0	0.6-1.2 (1.3)	2.0-4.0	0.55	0.15-0.55 (0.05-0.55)	0.15	0.55	3.0	0.35	0.15	0.20 (0.25)	
EN AB-47100	Al Si12Cu1(Fe)	10.5-13.5	0.6-1.1 (1.3)	0.7-1.2	0.55	0.35	0.10	0.30	0.55	0.20	0.10	0.15 (0.20)	

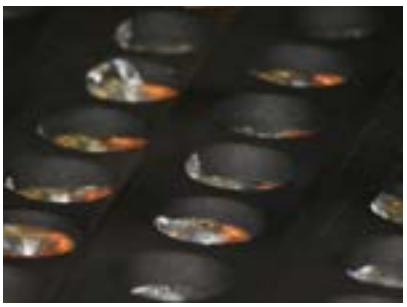
EN = European standard
AB = Aluminium ingots

Comments: The values in brackets are the composition of castings (EN AC), when they differ from ingots.

Alloys for die casting EN 1706		Mechanical properties EN 1706[1]					General description of properties	
Alloy designations: Numeric	ISO	Condi-tions[2]	Breaking strength R_m MPa[3] min.	Yield strength $R_{p0.2}$ MPa[3] min.	Elonga-tion A_{50} % min.	Brinell hardness HBS min.		
EN AC-43400	ISO Al Si10Mg(Fe)	DF	240	140	1	70	Near-eutectic alloy with excellent casting properties and good resistance to hot tearing. Good machinability as well as high chemical resistance.	
EN AC-44300	ISO Al Si12(Fe)(a)	DF	240	130	1	60	Eutectic alloy with excellent casting properties, excellent fluidity and high resistance to hot tearing. Good machinability as well as high chemical resistance.	
EN AC-44400	ISO Al Si9	DF	220	120	2	55	Near-eutectic alloy with excellent casting properties but with risk of adhesion to tools. Good resistance to hot tearing as well as high chemical resistance.	
EN AC-44500	ISO Al Si12(Fe)(b)	DF	240	140	1	60	Eutectic alloy with excellent casting properties. Good machinability with relatively high chemical resistance.	
EN AC-46000	ISO Al Si9Cu3(Fe)	DF	240	140	<1	80	Vey good castable universal alloy, especially suitable for die casting Slight tendency to sinking and forming internal porosity. Good machinability.	
EN AC-46100	ISO Al Si11Cu2(Fe)	DF	240	140	<1	80	Alloy with very good castability, excellent fluidity and good machinability.	
EN AC-46500	ISO Al Si9Cu3(Fe)(Zn)	DF	240	140	<1	80	Vey good castable universal alloy, especially suitable for die casting Slight tendency to sinking and forming internal porosity. Very good machinability.	
EN AC-47100	ISO Al Si12Cu(Fe)	DF	240	140	1	70	Eutectic alloy with excellent casting properties, excellent fluidity and high resistance to hot tearing. Good machinability.	

EN = European standard
AC = Component cast in aluminium

[1] Values given are only guideline values. This is the minimum value for separately cast bars with a thickness of 2.0 mm. Correct values can only be given by testing the whole component.



			Casting properties EN 1706						Heat treatment
	Other[2] each	Other[2] total	Solidification range** °C approx.	Casting temperature** °C approx.	Fluidity*	Resistance to hot tearing*	Shrinkage** % approx.	Density** approx. value kg/dm³	
	0.05	0.15	600-550	600-650	A	A	0.5-0.8	2.65	Normally not heat treated
	0.05	0.25	580-570	600-700	A	A	0.5-0.8	2.65	Not age-hardenable
	0.05	0.15	600-550	650-700	A	A	0.5-0.8	2.65	Not age-hardenable
	0.05	0.25	600-550	600-700	A	A	0.5-0.8	2.65	Normally not heat treated
	0.05	0.25	600-490	600-650	B	B	0.5-0.8	2.75	Normally not heat treated
	0.05	0.25	580-530	650-700	A	B	0.5-0.8	2.75	Normally not heat treated
	0.05	0.25	600-490	650-700	B	B	0.5-0.8	2.75	Normally not heat treated
	0.05	0.25	580-530	600-680	A	A	0.5-0.8	2.65	Normally not heat treated

[1] Composition with respect to Ti does not include titanium with compounds intended for grain refinement.
[2] "Other" does not include elements for grain refinement or purification of melt, such as Na, Sr, Sb and P.
* according to EN 1706 ** according to Aluminium Gusslegierung VAR

Classification: A=Excellent B=Good C=Fair D=Not recommended E=Unsuitable

	Possible uses	Mechanical and physical properties									
		Pressure sealing*	Strength	Machinability	Weld ability[4]	Corrosion resistance	Decorative anodization	Polishability	Linear expansion coefficient 20-100° C	Electrical conductivity MS/m	Thermal conductivity w/m K
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading, with high strength and good corrosion resistance.	C	B	B	C	C	E	B/C	$21x10^{-6}$	16-21	130-150
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading, with good corrosion resistance. Especially for difficult, thin-wall castings with good elongation.	C	B	C	D	C	E	D	$20x10^{-6}$	16-22	130-160
	For castings with requirements for toughness and corrosion resistance	C	C	C	D	C	E	D	$21x10^{-6}$	16-22	130-150
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading, with high strength and relatively good corrosion resistance.	C	B	C	D	C	E	D	$20x10^{-6}$	16-22	130-160
	For all-round use. Even for complicated thin-wall castings. Especially for die castings with high stresses.	C	B	B	F	D	E	C	$21x10^{-6}$	13-17	110-120
	For all-round use. Especially for thin-wall castings.	C	B	C	F	D	E	C	$20x10^{-6}$	14-18	120-130
	For all-round use. Even for complicated thin-wall castings. Especially for die castings with high stresses.	B	B	B	F	D	E	C	$21x10^{-6}$	13-17	110-120
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading	C	B	C	F	C	E	C	$20x10^{-6}$	15-20	120-150

[2] D F = Die casting, casting condition
[3] 1MPa = 1N/mm²
[4] The weldability of die castings depends on the quantity of internal gas and, in most cases, is very poor. With special die casting technology, *satisfactory to good weldability can be obtained.*

4 SAND AND CHILL CASTING ALLOYS.

Here we present the European standards for sand and chill casting. We show the chemical requirements for composition, casting properties, heat treatment, and mechanical properties. We also provide a description of the general properties as well as the possible areas of use. These are, of course, available in our product range, but if you wish we would be happy to help you produce the right alloy for your particular need.

Alloys for sand and chill casting EN 1676		Chemical composition for casting alloys EN 1676 (in weight %)											
Alloy designations according to:		Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Pb	Sn	Ti[1)]	
Numeric	Chemical formula												
EN AB-42000	Al Si7Mg	6.5-7.5	0.45 (0.55)	0.15 (0.20)	0.35	0.25-0.65 (0.20-0.65)	-	0.15	0.15	0.15	0.05	0.20 [3)] (0.25)	
EN AB-43000	Al Si10Mg(a)	9.0-11.0	0.40 (0.55)	0.03 (0.05)	0.45	0.25-0.45 (0.20-0.45)	-	0.05	0.10	0.05	0.05	0.15	
EN AB-43100	Al Si10Mg(b)	9.0-11.0	0.45 (0.55)	0.08 (0.10)	0.45	0.25-0.45 (0.20-0.45)	-	0.05	0.10	0.05	0.05	0.15	
EN AB-43200	Al Si10Mg(Cu)	9.0-11.0	0.55 (0.65)	0.30 (0.35)	0.55	0.25-0.45 (0.20-0.45)	-	0.15	0.35	0.10	-	0.15 (0.20)	
EN AB-44100	Al Si12(b)	10.5-13.5	0.55 (0.65)	0.10 (0.15)	0.55	0.10	-	0.10	0.15	0.10	-	0.15 (0.20)	
EN AB-44200	Al Si12(a)	10.5-13.5	0.40 (0.55)	0.03 (0.05)	0.35	-	-	-	0.10	-	-	0.15	
EN AB-44400	Al Si9	8.0-11.0	0.55 (0.65)	0.08 (0.10)	0.50	0.10	-	0.05	0.15	0.05	0.05	0.15	
EN AB-46200	Al Si 8Cu3	7.5-9.5	0.7 (0.8)	2.0-3.5	0.15-0.65	0.15-0.55 (0.05-0.55)	-	0.35	1.2	0.25	0.15	0.20 (0.25)	
EN AB-46400	Al Si9Cu1 Mg	8.3-9.7	0.7 (0.8)	0.8-1.3	0.15-0.55	0.30-0.65 (0.25-0.65)	-	0.20	0.8	0.10	0.10	0.18 [3)] (0.20)	
EN AB-47000	Al Si12(Cu)	10.5-13.5	0.7 (0.8)	0.9 (1.0)	0.05-0.55	0.35	0.10	0.30	0.55	0.20	0.10	0.15 (0.20)	

EN = European standard
AB = Aluminium ingots

Comments: The values in brackets are the composition of castings (EN AC), when they differ from ingots.

[1)] Composition with respect to Ti does not include titanium with compounds intended for grain refinement.
[2)] "Other" does not include elements for grain refinement or purification of melt such as Na, Sr, Sb, and P.
[3)] Lowest Ti content is not used if grain refinement is not relevant or is satisfied in another way.

		Casting properties						Heat treatment 5)
Other[2] each	Other[2] total	Solidi-fication range** °C approx.	Casting tempera-ture** °C approx.	Fluidity*	Resistance to hot tearing*	Shrink-age** % approx. 4)	Density** approx. value kg/dm³	
0.05	0.15	620-570	700-750	B	A	S:1-1.2 K:0.8-1	2.65	Solution annealing at 520-530° C for 3-6 hours, after which it is quenched and artificially aged at 150-175° C for 15-5 hours.
0.05	0.15	600-550	670-750	A	A	S:1-1.2 K:0.8-1	2.65	Solution annealing at 520-530° C for 3-6 hours, after which it is quenched and artificially aged at 150-175° C for 15-5 hours.
0.05	0.15	600-550	670-750	A	A	S:1-1.2 K:0.8-1	2.65	Solution annealing at 520-530° C for 3-6 hours, after which it is quenched and artificially aged at 150-175° C for 15-5 hours.
0.05	0.15	600-550	670-750	A	A	S:1-1.2 K:0.8-1	2.65	Solution annealing at 520-530° C for 3-6 hours, after which it is quenched and artificially aged at 150-175° C for 15-5 hours.
0.05	0.15	580-570	670-750	A	A	S:1-1.2 K:0.8-1	2.65	Cannot be artificially aged. Annealed at 520-530° C for 3-5 hours, after which it is quenched in water.
0.05	0.15	580-570	670-750	A	A	S:1-1.1 K:0.8-1	2.65	Cannot be artificially aged. Annealed at 520-530° C for 3-5 hours, after which it is quenched in water.
0.05	0.15	600-500	680-750	A	A	K:0.8-1	2.75	Not age-hardenable.
0.05	0.25	600-500	680-750	B	B	S:1-1.1 K:0.9-1	2.65	Not normally age hardened.
0.05	0.25	600-550	680-750	B	B	S:1-1.1 K:0.8-1	2.65	Solution annealed at 520-530° C for 3-6 hours, after which it is quenched in water and artificially aged at 150-175° C for 15-5 hours.
0.05	0.25	580-530	680-750	A	A	S:1-1.2 K:0.8-1	2.65	Not age-hardenable.

4) S = Sand casting
K = Chill casting

5) Shorter time and/or higher temperature for chill castings. Longer time and/or lower temperature for sand castings. The time is counted from when the temperature is reached.

Classification:
A=Excellent B=Good C=Fair
D=Not recommended E=Unsuitable

* according to EN 1706
** according to Aluminium Gusslegierung VAR

SAND AND CHILL CASTING ALLOYS CONT.

Alloys for sand and chill casting		Mechanical properties for separately cast test bars EN 1706					General description of properties	
Alloy designation according to: Numeric	ISO	Condi-tions[1]	Breaking strength R_m MPa[2] min.	Yield strength $R_{p0.2}$ MPa[2] min.	Elongation A_{50} % min.	Brinell hardness HBS min.		
EN AC-42000	ISO Al Si7Mg	SF ST6 KF KT6 KT64	140 220 170 260 240	80 180 90 220 200	2 1 2.5 1 2	50 75 55 90 80	Eutectic alloy with good casting properties. Good machinability, good weldability, and high chemical resistance.	
EN AC-43000	ISO Al Si10Mg(a)	SF ST6 KF KT6 KT64	150 220 180 260 240	80 180 90 220 200	2 1 2.5 1 2	50 75 55 90 80	Near-eutectic alloy with excellent casting properties and good resistance to hot tearing. Good machinability, excellent weldability, and high chemical resistance.	
EN AC-43100	ISO Al Si10Mg(b)	SF ST6 KF KT6 KT64	150 220 180 260 240	80 180 90 220 200	2 1 2.5 1 2	50 75 55 90 80	Near-eutectic alloy with excellent casting properties and good resistance to hot tearing. Good machinability, excellent weldability, and high chemical resistance.	
EN AC-43200	ISO Al Si10Mg(Cu)	SF ST6 KF KT6	160 220 180 240	80 180 90 200	1 1 1 1	50 75 55 80	Near-eutectic alloy with excellent casting properties and good resistance to hot tearing. Good machinability and excellent weldability.	
EN AC-44100	ISO Al Si12(b)	SF KF	150 170	70 80	4 5	50 55	Eutectic alloy with excellent casting properties, excellent fluidity and high resistance to hot tearing. Good machinability, excellent weldability, and high chemical resistance.	
EN AC-44200	ISO Al Si12(a)	SF KF	150 170	70 80	5 6	50 55	Eutectic alloy with excellent casting properties, excellent fluidity and high resistance to hot tearing. Good machinability, excellent weldability, and high chemical resistance.	
EN AC-44440	ISO A1 Si9	SF KF	170 180	80 90	4 5	50 55	Near-eutectic alloy with excellent casting properties and good resistance to hot tearing. Good machinability, excellent weldability and high chemical resistance.	
EN AC-46200	ISO Al Si8Cu3	SF KF	150 170	90 100	1 1	60 75	Very good castability, universal alloy. Slight tendency to sinking and forming internal porosity. Good machinability and good weldability.	
EN AC-46400	ISO Al Si9Cu1 Mg	SF KF KT6	135 170 275	90 100 235	1 1 1.5	60 75 105	Very good castability, universal alloy. Slight tendency to sinking and forming internal porosity. Good machinability and good weldability.	
EN AC-47000	ISO Al Si12(Cu)	SF KF	150 170	80 90	1 2	50 55	Eutectic alloy with excellent casting properties, excellent fluidity and high resistance to hot tearing. Good machinability, excellent weldability.	

EN = European standard
AC = Component cast in aluminium

[1] S = Sand casting
K = Chill casting
F = Cast conditions

[2] 1MPa = 1N/mm^2

T6 = Solution annealed and artificially aged.
T64 = Solution annealed and artificially aged (under-aged).
(The designations are equivalent to SS-EN 1706)

ALLOY KEYS.

Alloys for die casting

Europe EN 1706	Sweden SS	Germany VAR	US AA	Japan JIGS	UK BS	France NF	Italy UNI
43400		239 D		ADC3			
44300		230 D	A413.0	ADC2	LM20	A-S12	
44400	4255					AS-9	
44500	4263						
46000	4250	226 D		ADC10	LM24	A-S9U3	5075
46100				ADC12Z	LM2		
46500	4252	226/3		ADC10Z	LM24	A-S9U3X	4525
47100	4260	231D			LM20	A-S12U	5079

With reservations for any errors, there are no exact comparisons between the alloys. Instead comparable types of alloys are indicated.

	Possible uses	Mechanical and physical properties									
		Pressure-tightness*	Strength	Machinability	Weldability*	Corrosion resistance	Decorative anodization	Polishability	Linear expansion coefficient 20-200 °C	Electrical conductivity MS/m	Thermal conductivity W/m ^{0}K
	For complicated, pressure-tight castings subject to fatigue loading. Good corrosion resistance and high strength after heat treatment.	B	B	B/C	B	B/C	D	C	$22x10^{-6}$	19-25	150-170
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading Very good corrosion resistance and high strength after heat treatment.	B	B	B/C	A	B	E	D	$21x10^{-6}$	18-25	140-170
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading Good corrosion resistance and high strength after heat treatment.	B	B	B/C	A	C	E	D	$21x10^{-6}$	18-25	140-170
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading High strength after heat treatment but with limited properties regarding corrosion resistance.	B	B	B/C	A	C	E	C	$21x10^{-6}$	16-24	130-170
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading Good elongation and good corrosion resistance.	A	D	C	A	B/C	E	D	$20x10^{-6}$	16-23	130-160
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading Good elongation and very good corrosion resistance.	A	D	C	A	B	E	D	$20x10^{-6}$	17-24	140-170
	For castings that requires good toughness and resistance to corrosion.	C	C	C	D	C	E	D	$21x10^{-6}$	16-22	130-150
	For all-round use even for complicated thin-wall castings.	B	B	B	B	D	E	C	$21x10^{-6}$	14-18	110-130
	For all-round use even for complicated thin-wall castings.	B	A	B	B	D	E	D	$21x10^{-6}$	16-22	130-150
	For complicated, thin-wall, pressure-tight castings subject to fatigue loading, but with limitations regarding corrosion resistance and toughness.	A	D	C	A	C	E	C	$20x10^{-6}$	16-22	130-150

* according to EN 1706
** according to Aluminium Gusslegierung VAR

Classification:
A=Excellent B=Good C=Fair
D=Not recommended E=Unsuitable

Alloys for sand and chill casting

Europe EN 1706	Sweden SS	Germany VAR	US AA	Japan JIGS	UK BS	France NF	Italy UNI
42000	4244		356.0	AC4C	LM25	A-S7G	3599
43000	4253	239		AC4A, Al-Si 10 Mg			
43100	4253	239		AC4A, Al-Si 10 Mg		A-S10G	3051
43200	4253	233		AC4A			
44100	4261	230	B413.0	AC3A, Al-Si 12	LM6	A-S13	4514
44200	4261	230					
44400	4255					AS-9	
46200	4251	226	B380.1	AC4B	LM27	A-S7U3G	3601
46400							7369
47000	4260	231		Al-Si 12 Cu		A-S12U	3048

With reservations for any errors, there are no exact comparisons between the alloys. Instead comparable types of alloys are indicated.

5

STENAL460.

STENAL460 is a further development of the most common casting alloy EN AB-46000 (Al Si9Cu3(Fe)) with high-performance properties. The alloy has a tighter alloying range for favorable process effects and adjusted levels of alloying elements, which improves its properties. The alloy has a lower iron content, is alloyed with strontium and the manganese content is balanced against the iron content compared to a standard alloy.

The distinguishing properties of STENAL460 are high strength, good fatigue properties, and good plastic strain.

Apart from the excellent strength properties, the alloy gives a lower process variation, which provides good opportunities for lower discard levels. The lower porosity in die castings makes it possible to heat treat the component, which in turn makes it possible to tailor the properties to the application.

CHEMICAL COMPOSITION

Element	Min %	Max %
Si	8.70	9.40
Fe	0.5	0.60
Cu	2.70	3.30
Mn	0.30	0.47
Mg	0.35	0.45
Cr	-	-
Ni	-	0.30
Zn	-	1.20
Pb	-	0.20
Sn	-	0.10
Ti	0.05	0.10
Sr	0.030	0.05
Ca	-	0.003
P	-	0.002
Sb	-	0.005

Other elements, max 0.05% each. Total content of other elements, max 0.25%. The strontium level is higher in delivered ingots to allow for the burn off that takes place during remelting and holding. For finished castings, a suitable strontium level is 0.02-0.03%. For longer standstills, it may be necessary to add strontium.

MECHANICAL PROPERTIES

Yield strength $R_{p0.2}$ [MPa] min.	Breaking strength R_m [MPa] min	Elongation A_{25m} [%]	Brinell hardness $HB_{[5/250]}$ room temperature
Ac 220 (22)	361 (25)	2.8 (0.6)	118
Wc 226	352 (6)	2.6 (0.3)	123

- Stated values refer to air (ac) and water cooled (wc) separately cast test bars
- Standard deviation (1S) is given within brackets
- The real values depend on the casting process and cast geometry. A critical parameter is the casting thickness, where a thicker casting generally has a lower strength. Correct values can only be stated after sampling the whole component.

6 PRODUCT DESCRIPTION.

A description and pictures of our products follow below. All of our alloys can be delivered in the form of ingots, liquid aluminium, or drops. The ingots are stacked in batches, where two batches are banded together for more efficient handling. Drops are delivered loose on a loading platform or in big bags. All dimensions and weights are indicative; deviations may occur.

DROPS

Weight g	Height mm	Diameter bottom, mm	Diameter top, mm
70-120	35	40	30

INGOT

Weight kg	Height mm	Length mm	Width mm
6.5	60	600	90

PALLET (2 BATCHES TOGETHER)

Weight kg	Height mm	Length mm	Width mm
1000	750	1200	600

LIQUID

Liquid aluminium is delivered in specially built thermoses and each thermos holds up to 8 metric tonnes. A full loaded vehicle takes three thermoses per delivery.

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Fax +46 476 124 04
info@stenaaluminium.com
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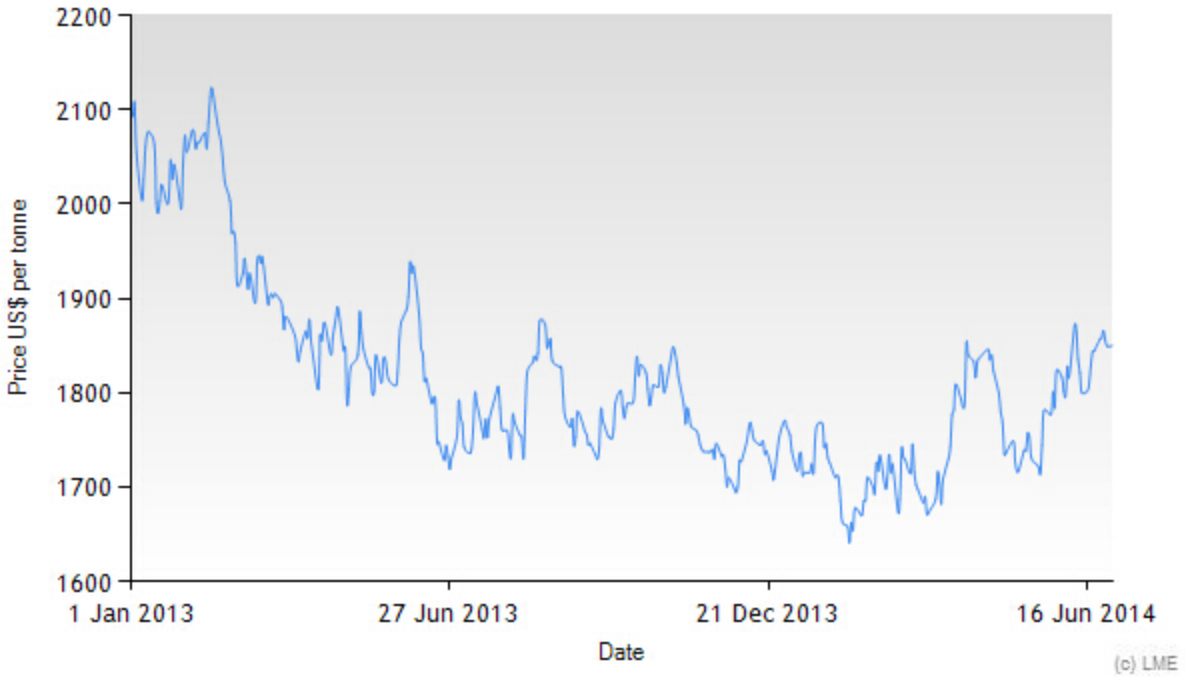
LME Aluminium

Historical price graph for Aluminium



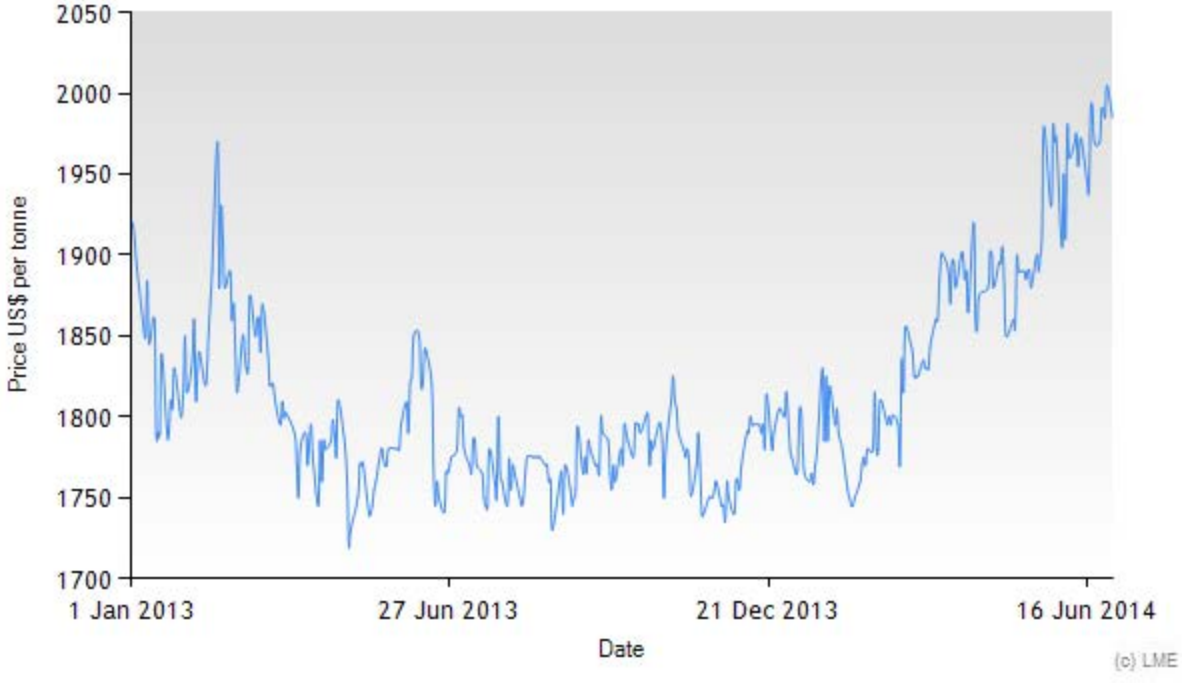
Select your own price graph date range

Date from 01 January 2013 Contract type Cash Buyer ?

Date to 30 June 2014 Update

LME Aluminium Alloy

Historical price graph for Aluminium Alloy



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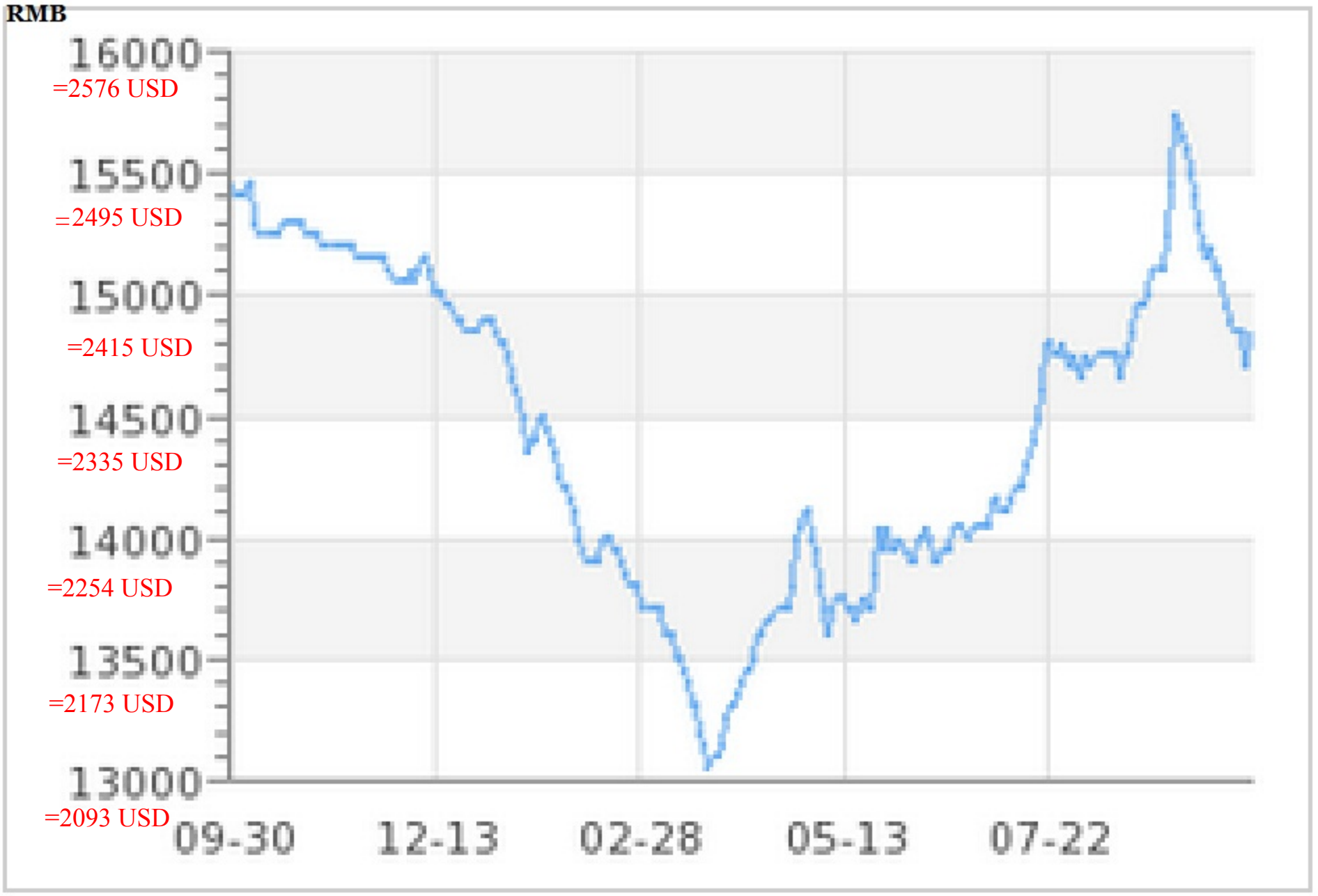
Date to: 30 June 2014

Contract type: Cash Buyer

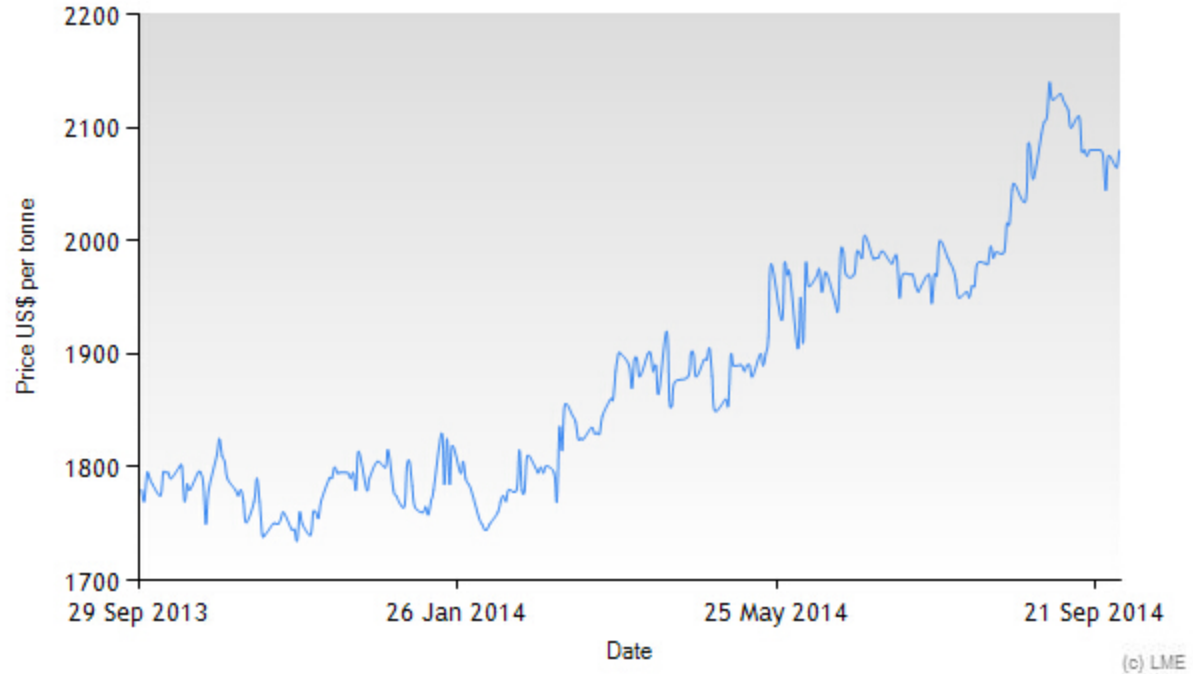
Update

Aluminum Alloy (A356) Price Chart ----SMM



1 Year Chart

Historical price graph for Aluminium Alloy ---LME



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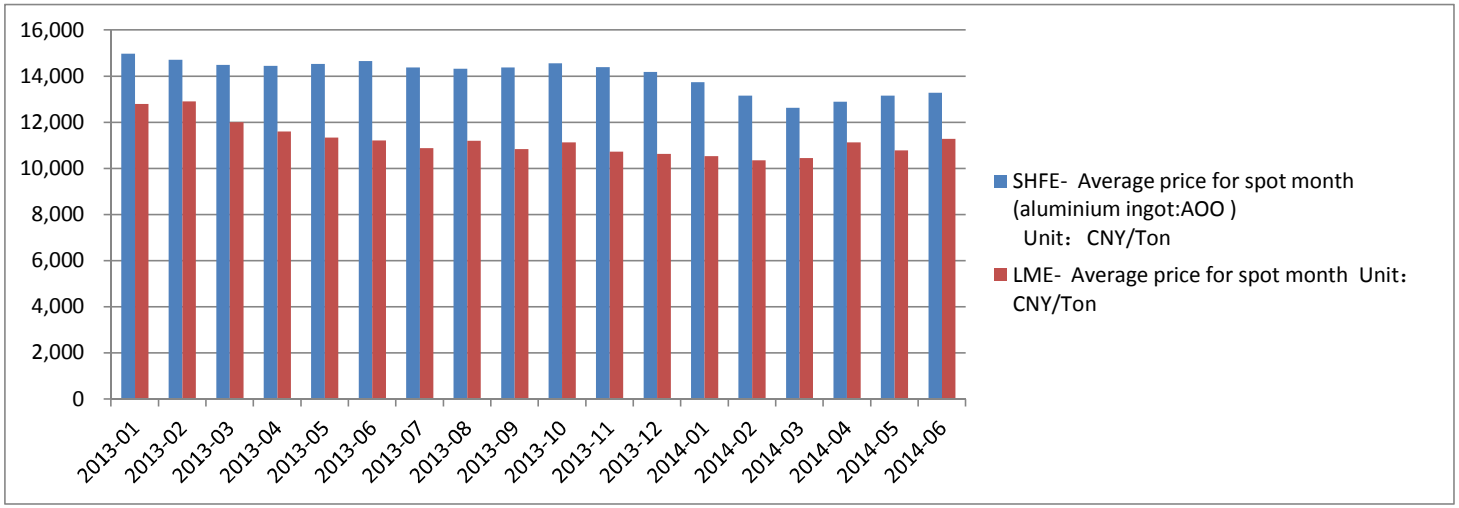
Date from 30 September 2013

Date to 30 September 2014

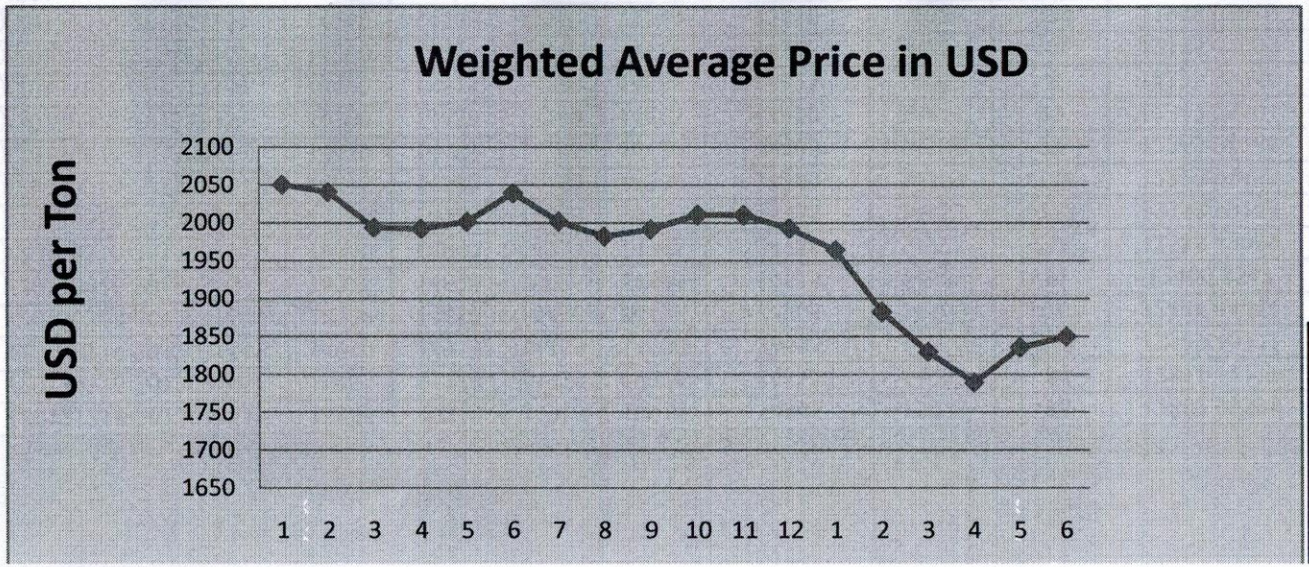
Contract type Cash Buyer

Update

Date	SHFE- Average price for spot month (aluminium ingot:AOO)	LME- Average price for spot month	LME- Average price for spot month	Exchange rate	Balance (Column B minus Column D)
	Unit：CNY/Ton	Unit：USD/Ton	Unit：CNY/Ton	USD/RMB	Unit：CNY/Ton
2013-01	14,977	2037.98	12,796	6.2787	2,181
2013-02	14,713	2053.43	12,904	6.2842	1,809
2013-03	14,490	1913.08	12,003	6.2743	2,487
2013-04	14,458	1856.52	11,598	6.2471	2,860
2013-05	14,530	1830.57	11,344	6.197	3,185
2013-06	14,661	1816.28	11,210	6.1718	3,451
2013-07	14,378	1763.67	10,886	6.1725	3,492
2013-08	14,332	1814.76	11,199	6.1708	3,133
2013-09	14,375	1760.4	10,842	6.1588	3,533
2013-10	14,559	1812.28	11,126	6.1393	3,432
2013-11	14,396	1749.21	10,735	6.1372	3,660
2013-12	14,192	1738.78	10,634	6.116	3,558
2014-01	13,749	1726.48	10,539	6.1043	3,210
2014-02	13,161	1693.85	10,354	6.1128	2,807
2014-03	12,629	1703.5	10,452	6.1358	2,176
2014-04	12,894	1809.65	11,139	6.1553	1,755
2014-05	13,156	1749.1	10,781	6.1636	2,375
2014-06	13,285	1834.4	11,292	6.1557	1,993



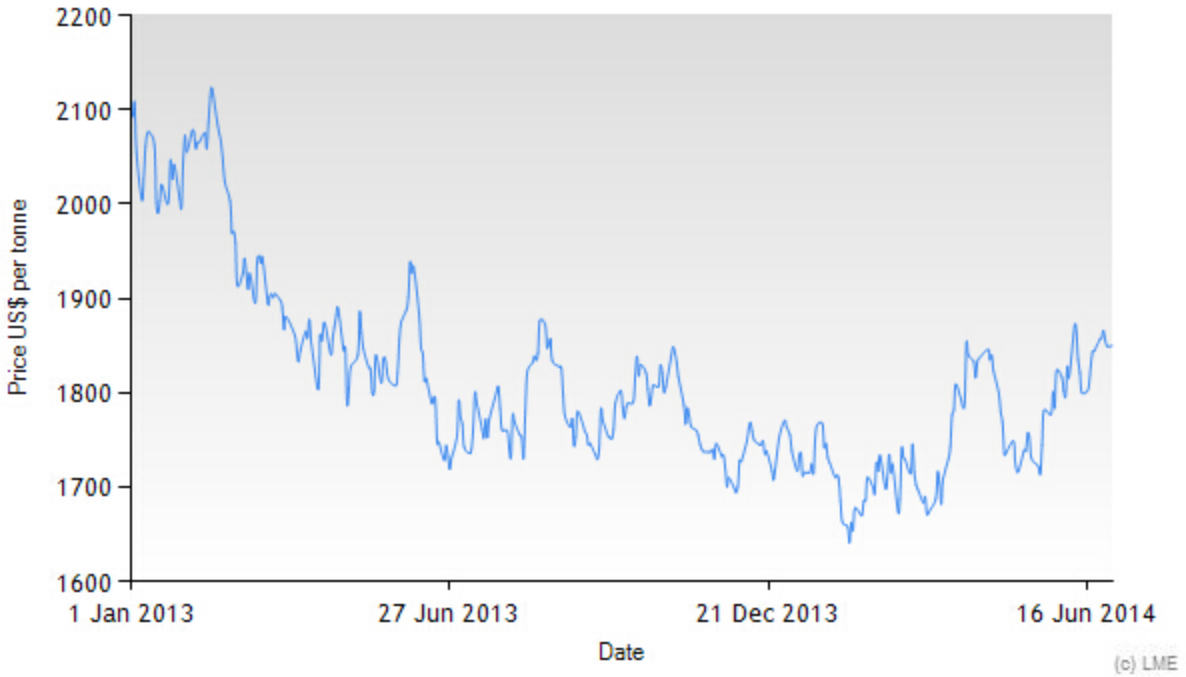
Species	Open	High	Low	Close	End of Period Settlement Price	Weighted Average Price	Net Change	Net of VAT	USD/CNY	Weighted Average Price in USD
al Spot Month(1301)(20121218-20130115)	15155	15210	14915	14915	14945	15073	-96	12882.90598	6.2842	2050.0471
al Spot Month(1302)(20130116-20130218)	15065	15110	14770	14775	14815	14989	-84	12811.11111	6.2787	2040.408223
al Spot Month(1303)(20130219-20130315)	14900	14915	14355	14600	14595	14636	-353	12509.40171	6.2743	1993.752564
al Spot Month(1304)(20130318-20130415)	14580	14680	14430	14430	14505	14560	-76	12444.44444	6.2471	1992.035416
al Spot Month(1305)(20130416-20130515)	14025	14620	14025	14535	14525	14509	-51	12400.8547	6.197	2001.106132
al Spot Month(1306)(20130516-20130617)	14540	14940	14225	14765	14780	14725	216	12585.47009	6.1725	2038.958297
al Spot Month(1307)(20130618-20130715)	14725	14725	14300	14330	14355	14453	-272	12352.99145	6.1718	2001.521672
al Spot Month(1308)(20130716-20130815)	14315	14580	14150	14350	14350	14309	-144	12229.91453	6.1708	1981.900974
al Spot Month(1309)(20130816-20130916)	14430	14485	14205	14420	14405	14348	39	12263.24786	6.1588	1991.174882
al Spot Month(1310)(20130917-20131015)	14300	14650	14240	14415	14450	14441	93	12342.73504	6.1393	2010.446638
al Spot Month(1311)(20131016-20131115)	14400	14515	14130	14300	14325	14433	-8	12335.89744	6.1372	2010.020439
al Spot Month(1312)(20131118-20131216)	14290	14365	14110	14110	14225	14257	-176	12185.47009	6.116	1992.3921
al Spot Month(1401)(20131217-20140115)	14160	14200	13510	13540	13530	14026	-231	11988.03419	6.1043	1963.867141
al Spot Month(1402)(20140116-20140217)	13580	13800	12880	13330	13300	13464	-562	11507.69231	6.1128	1882.556653
al Spot Month(1403)(20140218-20140317)	13420	13420	12805	12825	12830	13133	-331	11224.78632	6.1358	1829.392471
al Spot Month(1404)(20140318-20140415)	12900	13175	12510	13070	13060	12843	-290	10976.92308	6.1358	1788.996231
al Spot Month(1405)(20140416-20140515)	13075	13555	12915	13010	13020	13235	392	11311.96581	6.1636	1835.285517
al Spot Month(1406)(20140516-20140616)	13045	13655	12925	13300	13310	13322	87	11386.32479	6.1557	1849.720549



Note:
Species: al spot Month
Price: Net of VAT and in USD under the then exchange rate
Standard product: aluminum ingots with no less than 99.70% aluminum content

LME Aluminium

Historical price graph for Aluminium



Select your own price graph date range

Date from 01 January 2013 Contract type Cash Buyer ?

Date to 30 June 2014 Update

税则号列 HS Code	货品名称 Article Name	最惠(%) MFN	普通 GT	增值税率 VAT	出口退税 Export rebate	计量单位 Unit	监管条件 Supervision conditions	Article Description
76.01	未锻轧铝：							**Unwrought aluminium:**
	-非合金铝：							-Aluminium, not alloyed:
7601.1010	---按重量计含铝量在99.95%及以上	5	14	17		千克	KG	---Containing by weight 99.95% or more of aluminium
7601.1090	---其他	0	14	17		千克	KG	---Other
7601.2000	-铝合金	7	14	17		千克	KG	-Aluminium alloys

Aluminium alloy Engineering use

Source:Internet | Published:2011-5-2 | Views:573

Overview

Aluminium alloys with a wide range of properties are used in engineering structures. Alloy systems are classified by a number system (ANSI) or by names indicating their main alloying constituents (DIN and ISO). Selecting the right alloy for a given application entails considerations of its tensile strength, density, ductility, formability, workability, weldability, and corrosion resistance, to name a few. A brief historical overview of alloys and manufacturing technologies is given in Ref. Aluminium alloys are used extensively in aircraft due to their high strength-to-weight ratio. On the other hand, pure aluminium metal is much too soft for such uses, and it does not have the high tensile strength that is needed for airplanes and helicopters.

Previous:Aluminium alloy designations
Next:Aluminium alloy heat sensitivity considerations

Related Articles

- Aluminium(Aluminum)
- 6063 aluminium alloy Mechanical properties
- 6063 aluminium alloy
- Aluminium alloy designations
- Aluminium alloy Engineering use
- Aluminium alloy
- 6063 aluminium alloy Basic properties
- 6063 aluminium alloy Uses
- 6063 Aluminium Extrusions
- Aluminum Extrusion production process
- Aluminium alloy heat sensitivity considerations
- Aluminium alloys versus types of steel

铝合金的用途

http://www.alu.cn 2010/9/28 来源:中国铝业网 作者:范琪 点击数： 1692 次 繁体版

铝合金使用范围：

一、板带的应用广泛应用于装饰、包装、建筑、运输、电子、航空、航天、兵器等各行各业。

二、航空航天用铝材用于制作飞机蒙皮、机身框架、大梁、旋翼、螺旋桨、油箱、壁板和起落架支柱，以及火箭锻环、宇宙飞船壁板等。

三、交通运输用铝材用于汽车、地铁车辆、铁路客车、高速客车的车体结构件材料，车门窗、货架、汽车发动机零件、空调器、散热器、车身板、轮毂及舰艇用材。

四、包装用铝材全铝易拉罐制罐料主要以薄板与箔材的形式作为金属包装材料,制成罐、盖、瓶、桶、包装箔。广泛用于饮料、食品、化妆品、药品、香烟、工业产品等包装。

五、印刷用铝材主要用于制作PS版，铝基PS版是印刷业的一种新型材料，用于自动化制版和印刷。

六、建筑装饰用铝材铝合金因其良好的抗蚀性、足够的强度、优良的工艺性能和焊接性能、广泛用于建筑物构架、门窗、吊顶、装饰面等。如各种建筑门窗、幕墙用铝型材、铝幕墙板、压型板、花纹板、彩色涂层铝板等。

七、电子家电用铝材主要用于各种母线、架线、导体、电气元件、冰箱、空调、电缆等。

国际上已经注册的铝合金牌号有1000多个，每个牌号又有多种状态，在硬度，强度，耐蚀性，加工性，焊接性，装饰性等方面都存在着明显的差异。选择铝合金的牌号与状态时，以上各方面很难同时满足，也没有必要，应根据产品的性能要求，使用环境，加工过程等因素，设定各种性能的优先次序，方可做到合理选材，在保证性能的前是下合理控制成本。

硬度：很多客户在购买铝时非常关心，硬度首选跟合金化学成份有直接的关系。其次，不同的状态也影响较大，从所能达到的最高硬度来看，7系，2系，4系，6系，5系，3系，1系，依次降低。

硬度：强度是产品设计时必须考虑的重要因素，成其是铝合金组件作为组件时，应根据所承受的压力，选择适当的合金。纯铝强度最低，而2系及7系热处理型合金度最高，硬度和强度有一定的下相关系。

耐蚀性：耐蚀性包括化学腐蚀，耐应力腐蚀等性能。一般而言，1系纯铝的耐蚀性最佳，5系表现良好，其次是3系和6系，2系及7系较差。耐蚀性选用原则应根据其使用场合而定。高强度合金腐蚀环境下使用，必须使用各种防蚀用复合材料。

加工性：加工性能包插成形性能与切削性能。因为成形性与状态有关，在选择铝合金牌号后，还需考虑各种状态的强度范围，通常强度高的材不易成形。台果要对铝材进行折弯，拉伸，深冲等成形加工，完退火状态材料的成形性最佳，反之，热处理状态材料的成形性最差。铝合金的切削性较差，对于模具，机械零件等需要切削性较佳，反之，低强度者切削性较差，对模具，机械零件等需要切削加工的产品，铝合金的切削性是重要的考虑因素。

焊接性：多数铝合金的焊接性均无问题，尤其是部分5系列的铝合金，是专为焊接考虑而设计的，相对面言，部分2系和7系的铝合金较难焊接。杭州光越金属材料有限公司。

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2014年投产、在建的铝挤压项目
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长江有色金属现货下午快讯2月3日(铜铝铅锌锡镍)
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重磅利好成就多头狂欢日 国内商品年内罕见大爆发
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铝卷，铝板，合金铝板，合金铝卷
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铝型材生产铝型材厂家 财鑫铝
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成功故事 更多

装饰性能：铝材应用于装饰或某些特定的场合时，需要对其表面进行阳极氧化，涂装等加工，以获得相应的颜色和表面组织，这时其装饰性应该重点考虑的，一般而言，耐蚀性较好的材料，其阳极处理性能，表面处理性能，涂装性能都非常出色。

上一篇：稀土价格暴涨 南方多地私挖滥采冲动再起 【回到顶部】

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热门关键词： 铝板 铝棒 铝带 铝管

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铝合金电缆与普通电缆的区别
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分享

Usage of aluminum alloy

http://www.alu.cn 2010/9/28
Source: China Aluminum Network Author: Fan Qi

1. Board tapes are widely used in decoration, packaging, construction, transportation, electronic, aviation, spaceflight, weapons and so on all walks of life

2. Aluminum materials for aerospace are used in making aircraft skin, body frame, truss, rotor, propeller, fuel tank, wall plate and the landing gear strut, and the rockets forging ring, spacecraft wall plate, etc

3. Aluminum materials for transportation are used in body structure material of automobile, subway, high-speed passenger vehicles, railway passenger car, car doors and Windows, shelves, automobile engine parts, air conditioner, radiator, panels, wheel hub and ship material

4. Aluminum materials for packing are all aluminum beverage cans which are mainly made in the form of sheet and foil, and made into metal cans, lid, bottles, barrels, foil packing. They are widely used in beverage, food, cosmetics, medicine, cigarette, industrial products and other packaging.

6. Aluminum materials for printing are mainly used for PS plate. Aluminum base PS plate is a kind of new materials, printing for automated plate making and printing

6. Aluminum alloy for architectural decorative is widely used in building structure, doors and Windows, ceiling, decorative surface, such as all kinds of building doors and Windows, curtain wall with aluminum, aluminum curtain wall plate, pressure plate, decorative pattern plate, color coating sheets, etc because of its good corrosion resistance, sufficient strength, excellent process performance and welding performance.

7. Aluminum materials for electronic appliances is mainly used for various bus, wiring, conductor, electrical components, refrigerator, air conditioning, cable, etc

There are more than 1,000 aluminum alloy grades registered in international

community, each grade there are a variety of state, hardness, strength, corrosion resistance, formability, weldability, decorative, etc. There are obvious differences. When selecting grade aluminum and state, is difficult to satisfy the above aspects, it is not necessary, should be based on product performance requirements, the use of environmental factors, such as process, setting priorities for various properties before they make a reasonable selection before the performance is guaranteed under reasonable control costs

Hardness: many customers are very concerned about when buying aluminum, hardness, chemical composition of alloys of choice with a direct relationship. Second, the various states have a greater impact from the highest possible hardness of view, the 7 Series, 2 lines, 4 lines, 6 Series, 5 Series, 3 Series, 1 Series, in descending order.

Hardness: Strength is an important factor that must be considered in product design, as it is the aluminum alloy component as the component should be based on the pressure, select the appropriate alloy. Minimum strength aluminum, and 2 and 7 Series highest heat-type alloy, hardness and strength of certain lower phase relationship.

Corrosion resistance: corrosion resistance, including chemical corrosion, stress corrosion and other properties. In general, a system the best corrosion resistance of aluminum, 5 and performed well, followed by the 3 Series and 6 Series, 7 Series 2 system and poor. Corrosion resistance selection should be based on the principle of the use of the occasion. High-strength alloy corrosion environments, you must use a variety of composite materials for corrosion protection.

Processing: processing performance package insert forming properties and cutting performance. Because with the state of formability, the choice of alloy grades, the need to consider the strength of the scope of the various states, usually forming high strength materials is not easy. If Taiwan were to be on the aluminum bending, stretching, deep drawing and other forming process, complete the forming of the annealed condition the best materials on the contrary, the material forming heat treatment of the worst. Poor cutting aluminum alloy, for molds, machinery parts and other necessary cutting of better contrast, low intensity were poor machinability of the

mold, machine parts and other products require cutting, cutting of aluminum is important considerations.

Welding: aluminum welding majority had no problems, especially some 5 series aluminum alloy, is designed for welding into account the relative surface of words, Part 2 and 7 Series aluminum welding more difficult. Hangzhou Guangyue Metal Materials Co., Ltd.

Decorative properties: aluminum used in decoration or certain situations, it needs to surface anodizing, painting and other processing, in order to obtain the corresponding color and surface structure, then the focus should be considered decorative, general and words, better corrosion resistance material, anodizing, surface processing performance, painting and performance are excellent.

铝合金的用途指南

铝合金系统	合金称呼		材料特性的概要	用途例
	JIS	A.A		
纯铝系	1060	1060	导电材 61%IACS 保证，强度必要时使用 6101	导电板、电线
	1085 1080 1070 1050 1N30	1085 1080 1070 1050 --	成形性、表面处理性良好、耐蚀性是铝合金中最好的合金。强度依铝的纯度而减少。	日用品、铭板、照明器具、反射板、装饰品、化学工业槽、散热片、溶接线、导电材、印刷板
	1100 1200	1100 1200	纯度在 99%以上的一般用途铝。在阳极氧化后外观稍稍泛白，此外其它特性与上述合金相同。	一般器物、散热鳍片、建材、热交换器零件
	1N00	--	比 1100 强度稍高，挤压性良好。其它特性同 1100。	日用品
Al-Cu 系	2011	2011	切削性良好、强度高、耐蚀性差。要求耐蚀性的场合使用 6262 合金。	旋钮、光学零件、螺丝
	2014 2017 2024	2014 2017 2024	因为铜含量高、耐蚀性、强度高、使用在构造用材料，也适用于锻造品。	航空飞机、齿轮、油压零件、自行车轮鼓
	2117	2117	固溶化处理后，作为铆钉、铆扣材料。	铆钉、铆扣
	2018 2218	2018 2218	锻造性良好、高温强度高，适用于要求耐热性的锻造零件，耐蚀性差。	气缸盖、活塞、VTR 气缸
	2618	2618	高温强度高、耐蚀性差	活塞、橡胶成型用的模具、一般耐热用零件
	2219	2219	高温、低温的强度特性良好、溶接性也良好、但耐蚀性差	低温用储槽、航天机器
	2025	2025	锻造性良好、强度高、耐蚀性差	螺旋桨、磁性鼓
	2N01	--	耐热性佳、强度高、耐蚀性差	飞机引擎、油压零件
Al-Mn 系	3003 3203	3003 -	强度比 1100 高、成形性、溶接性、耐蚀性良好	散热片、化妆板、复印机轮鼓、车用空调部品、船舶用材
	3004 3104	3004 3104	强度比 3003 高、成形性、耐蚀性良好	铝罐体、灯泡头、彩色铝
	3005	3005	强度比 3003 高大约高 20%、耐蚀性比较好	建材、彩色铝
	3105	3105	强度比 3003 高，其它特性与 3004 类似	建材、彩色铝

Al - Si 系	4032	4032	耐热性、耐磨性良好、热膨胀性系数小	活塞、油缸盖、
	4043	4043	流动性良好、凝固收缩小。阳极处理后自然发色呈灰色	溶接线、建筑面板、硬焊薄片
Al - Mg 系	5005 --	5005 5050	强度与 3003 相同、加工性、溶接性、耐蚀性、阳极处理后表面良好，与 6063 型材色泽调合	建筑用内外装、车辆内装、船舶内装
	5052	5052	中程度强度的代表性合金，耐蚀性、溶接性、成形性良好、耐海水性良好，	一般板金、船舶、车辆、建筑、铝罐体盖、
	5652	5652	限制 5052 的不纯物元素，能抑制过氧化氢的分解，其它特性同 5052	过氧化氢的容器
	5154	5154	强度比 5052 高约 20%	同 5052、压力容器
	5254	5254	限制 5154 的不纯物元素，能抑制过氧化氢的分解，其它特性同 5154	过氧化氢的容器
Al - Mg 系	5454	5454	强度比 5052 高约 20%。严格的环境下耐蚀性比 5154 要良好	汽车轮圈
	5056	5056	耐蚀性良好、可利用切削加工增加表面光亮、阳极处理性和染色性良好	相机镜框、通信机器零件、栓件
	5082	5082	与 5083 强度接近、成型、耐蚀性良好	罐盖
	5182	5182	强度比 5082 高约 5%，其它特性与 5082 相同	罐盖
	5083	5083	溶接构造性合金，实用非热处理合金当中，强度较高，耐蚀性合金，用于溶接构造，耐海水性，低温性良好	轮船、车辆、低温储槽、压力容器
	5086	5086	强度比 5154 高，耐海水性良好的非热处理溶接构造合金	轮船、压力容器、磁盘
	5N01	--	强度与 3003 大致相同，光辉热处理后的阳极氧化处理可得到高度光辉性，成型性、耐蚀性良好	厨房用品、照相机、铭板
	5N02	--	铆钉用合金，耐海水性良好	铆钉
Al - Mg - Si 系	6061	6061	热处理型耐蚀合金，虽然 T6 处理后可得到相当高的降伏强度，但溶接接头强度较低，需再重新做 T4、T6 处理，否则以螺栓和铆钉接合，为一般构造用使用量最多的一种合金。	车辆、陆上构造物、自行车架、运动器材、休闲用品
	6N01	--	强度和挤压性介于 6061 与 6063 之间，可以风淬得到接近 6061 的强度，适合形状复杂、大型的薄壁型材，耐蚀性溶接性良好	车辆的箱体、自行车轮圈、

	6063	6063	挤压的代表性合金，强度虽比 6061 低，挤压特性优异，可得到复杂的断面形状，耐蚀性，表面处理性良好。	建筑用型材、窗用、铝围幕、家具、体闲运动器材、散热片
	6101	6101	高强度导电用材料，55%IACS 保证，	电线、导电板
	6151	6151	特别是用于锻造加工性，耐蚀性，表面处理性也良好的复杂锻造品	机械、汽车零件
	--	6262	耐蚀易切削性合金，耐蚀性和表面处理性比 2011 良好，具有 6061 同等的强度。	镜头本体、气化器零件、刹车零件、瓦斯器具零件
Al - Zn - Mg 系	7072	7072	电极电位低，主要用于防蚀目的的披覆材料，利用牺牲阳极作用，适用于热交换器的散热鳍片	披覆材料、鳍片
	7075	7075	铝合金中强度最高的一种合金，耐蚀差，需用 7072 作为披覆材，改善耐蚀性	航空飞机、滑雪杆
	7050	7050	淬火性改良型合金，耐应力腐蚀龟裂性良好，适合厚板锻造品	航空飞机、高速回转体
	7N01	--	溶接构造用合金，强度高，且溶接部常温放置后能够回复到与母材相近的强度、耐蚀性相当良好	捷运车箱用梁、自行车架、机车车架、大型构造物
	7003	7003	溶接构造用合金，强度虽然比 7N01 稍低，但挤压特性良好，能够得到薄壁大型型材，其它特性同 7N01	捷运车箱用梁、自行车架、机车车架、大型构造物、机车圈
Al - Fe 系	8021	8021	含有高量的铁，比 1N30 强度高，伸长率和展压性良好的铝箔用合金。	包装用、电器通信用
	8079	8079	含有高量的铁与硅，比 1N30 强度高，伸长率和展压性良好的铝箔用合金。	包装用、电器通信用

Usage guidelines of Aluminum Alloy

Aluminum Alloy system	Name of Alloy		Summary of material properties	Examples of End Usages
	JIS	A.A		
Pure aluminum system	1060	1060	Conductive material 61% IACS guarantee, use 6101 when the intensity is necessary	Conductive plate, wire
	1085 1080 1070 1050 1N30	1085 1080 1070 1050 --	Rational good formability, surface, the corrosion resistance is the best alloy of aluminum alloy. Strength depends on the purity of aluminum.	Daily consumer goods, name plate, lighting appliances, baffle plate, decoration, chemical industry sinks, cooling fin, soluble wiring, printing plate
	1100 1200	1100 1200	The general use of above 99% purity aluminum. In anodic oxide after slightly bleached appearance, same as the above alloy and other characteristics.	General items, the cooling fins, building material, heat exchanger parts
	1N00	--	A little higher than 1100 strength, extrusion is good. Other characteristics are same as 1100.	Daily commodities
Al - Cu system	2011	2011	Good machinability, high strength, poor corrosion resistance. Use of 6262 alloy on corrosion resistance occasion.	Knobs, optical parts, screws
	2014 2017 2024	2014 2017 2024	Because of the high copper content, corrosion resistance, high strength, materials used in construction, can also be applied to forgings	Aviation aircraft, drum gear, oil pressure parts, bicycle wheel
	2117	2117	After solution treatment, as the rivet, rivet buckle material.	Rivet, rivet clasp
	2018 2218	2018 2218	Forging good, high temperature and high strength, suitable for request the thermal resistance of the forging parts, corrosion resistance is poor.	Cylinder head, piston, VTR cylinder
	2618	2618	High temperature high strength, corrosion resistance is poor	Piston, mold in rubber molding, general heat-resistant parts
	2219	2219	Good strength properties of high temperature and low temperature, dissolves, also good is good, but poor corrosion resistance	Cryogenic storage tank, space machines

	2025	2025	Forging good, high strength, corrosion resistance is poor	Screw, magnetic drum
	2N01	--	Good heat resistance, high strength, corrosion resistance is poor	Aircraft engine, hydraulic parts
Al - Mn system	3003 3203	3003 -	Strength is higher than 1100, formability, dissolves resistance, good corrosion resistance	Heat sink, makeup plate, copier wheel drum, automotive air conditioning parts, ships material
	3004 3104	3004 3104	Strength is higher than 3003, formability, good corrosion resistance	Aluminum tank, bulbs head, color aluminum
	3005	3005	Strength is about 20% higher than 3003, better corrosion resistance	Building materials, color aluminum
	3105	3105	Strength is higher than 3003, other characters are same as 3004	Building materials, color aluminum

Al - Si system	4032	4032	Good heat resistance, abrasion resistance, small thermal expansion coefficient	Piston and cylinder head
	4043	4043	Good liquidity, solidification shrink. Since the natural hair color is gray after anodization	Soluble wiring, building panels, brazing thin slices
Al - Mg system	5005 --	5005 5050	Strength is the same as 3003, processability, dissolves after anodizing, corrosion resistance, good surface, blending with 6063 type material color	Building inside and outside outfit, vehicles built in, ships built in
	5052	5052	Representation alloys of the medium degree of strength, Corrosion resistance, dissolves, good formability, good water resistance	General sheet metal tanks, vessels, vehicles, buildings, aluminum can cover
	5652	5652	Limit the impurity content of 5052 elements, inhibit the decomposition of hydrogen peroxide, other characters are same as 5052	Containers of hydrogen peroxide
	5154	5154	The intensity is about 20% higher than 5052	Same as 5052, pressure vessel
	5254	5254	Limit the impurity content of 5154 elements, inhibit the decomposition of hydrogen peroxide, other characters are same as 5154	Containers of hydrogen peroxide

Al - Mg system	5454	5454	The intensity is about 20% higher than 5052. Corrosion resistance is better than 5154 in the strict environment	automotive rim
	5056	5056	Good corrosion resistance, increased available machining light is bright, good anodic process and dyeing	camera frame, communication machine parts, bolt
	5082	5082	close to 5083 strength, forming, good corrosion resistance	canner end
	5182	5182	The intensity is about 5% higher than 5082, other characters are same as 5082	canner end
	5083	5083	Alloy dissolves , practical non heat-treated alloy, high strength, corrosion resistance of alloy, used to make up dissolves structure, water resistance, good low temperature	Ships, vehicles, low temperature storage tank, pressure vessel
	5086	5086	Seawater resistance strength is higher than 5154, not hot place dissolves alloy with good structure	ship, pressure vessel, disk
	5N01	--	Strength is roughly same with 3003, glorious anodic oxidation treatment after heat treatment can get high brightness, good formability, corrosion resistance	Kitchen supplies, camera, nameplate
	5N02	--	Rivet alloy, good water resistance	rivet
Al - Mg - Si system	6061	6061	Heat treatment corrosion resistant alloy, although after T6 treatment available to quite a high yield strength, but the joint strength is low, must do T4 and T6 treatment again, otherwise the screw bolt and rivet joint, for the most general structure with the use of an alloy.	Vehicles, land structure, frame of bicycle, sports equipment and leisure goods
	6N01	--	Strength and compressional are between 6061 and 6063, wind quenching intensity can be obtained is nearly 6061, is suitable for complex shape, large thin wall profile, good corrosion resistance dissolves	Vehicle container, Bicycle rims

	6063	6063	Representative alloy extrusion, strength is less than 6061, extrusion, features excellent complex cross-section shapes can be obtained, corrosion resistance, good Variety of Attractive Appearance	Building material, window, Aluminum side curtain,furniture, spare sports equipment and cooling fin
	6101	6101	High strength and conductive materials, 55% IACS guarantee	Electric wire, conductive plate
	6151	6151	Especially for forging process, corrosion resistance, surface complex forging process is also good	Machinery, auto parts
	--	6262	Good alloy corrosion resistant free-cutting, good corrosion resistance and surface process than 2011, equal strength is same as 6061	Lens ontology, carburetor parts, brake parts, gas appliance parts
Al - Zn - Mg system	7072	7072	Low electrode potential, it is mainly used for the purpose of corrosion on the sheathing material, using sacrificial anode effect, is suitable for heat exchanger heat dissipation fins	Coating, fins
	7075	7075	The highest strength of aluminum alloy in the alloy, corrosion resistance is poor, need 7072 as cladding material to improve the corrosion resistance	Aviation aircraft, ski poles
	7050	7050	Quenching improved type alloy, good resistance to stress corrosion cracking, suitable for thick plate forgings	Aviation aircraft、High speed rotors
	7N01	--	Dissolves alloy structure, high intensity, and dissolves after normal temperature place can reply to close to the base strength, corrosion resistance is quite good	beam in MRT trunk, bicycle frame, motorcycle frame, large structure
	7003	7003	Dissolves alloy structure, though a little lower than 7N01 intensity, but squeezing properties is good, can get thin wall large profiles, other features with 7N01	beam in MRT trunk, bicycle frame, motorcycle frame, large structure, locomotive circle
Al - Fe	8021	8021	Contains a high amount of iron, more than 1N30 high strength, elongation and the aluminum foil alloy with good pressure	Packaging, electronics and communication
	8079	8079	Contains high amount of iron and silicon, is higher than 1N30 strength, elongation and the aluminum foil alloy with good pressure	Packaging, electronics and communication

All export of aluminium from July 2008 to June 2014				
CN Code	**Description**	**Period**	**Volume (Ton)**	**Value (Ten thousands dollar)**
76012000	Aluminium alloy	July 2008-June 2014	2,798,200.1	672,045.8

All import of aluminium from July 2008 to June 2014				
CN Code	**Description**	**Period**	**Volume (Ton)**	**Value (Ten thousands dollar)**
76012000	Aluminium alloy	July 2008-June 2014	824,888.9	174,379.4

Consumption and users / User Sectors	Consumption proportion of primary aluminium by user sector (Year 2012)	Number of above threshold enterprises in user sectors (Year 2012/2011)	Sectors where number of enterprise are collected and listed	对应统计局具体行业企业名称
Construction	33.45%	72,280	Construction	建筑业企业
Transportation equipment	19.78%	15,012	Transportation equipment	交通运输设备制造业规模以上工业企业
Electric power generation and transmission facilities	11.41%	20,084	Electric power generation and transmission facilities	电气机械及器材制造业规模以上工业企业
Package material (fast food restaurant)	9.56%	26178	Fast food, food processing and manufacturing, drinks production, tobacco production, medicion manufacturing	主要是速食食品和快餐行业=快餐连锁门店数(其中:外商投资快餐连锁门店数)+食品加工制造+饮料制造+烟草加工+医药制造
Machinery Manufacturing	8.21%	39,766	General and special machine and equipment building	通用设备制造，专用设备制造,
Daily consumer goods	8.25%	8781	Instrument & meters, cultural & office machines, crafts works	主要是仪器仪表文化办公机械+工艺品
Telecommunication instruments	4.25%	11,364	Telecommunication instruments, computer, other electronic instruments	通信设备、计算机及其他电子设备制造规模以上工业企业
Others	5.09%	10000	covering several dozens of sectors in estimation	估计有几十个不同的行业
Total	100.00%	203,465		
Source: Data in column B: CNIA, data in column C: NBS				

Production of Primary aluminium and Aluminium alloy

Product Name	Unit of measurement	2011(Jan-Jun)	2011(Jan-Dec)	2012(Jan-Jun)	2012(Jan-Dec)	2013(Jan-Jun)	2013(Jan-Dec)	2014(Jan-Jun)	POR
Primary aluminium	MT (Ten thousands)	864.3	1755.5	950.5	1988.3	1058	2204.7	1154.2	2300.9
Aluminium alloy	MT (Ten thousands)	180.4	378.2	214.8	480.3	274.6	592.8	290.1	608.3

Source: NBS

北京1个	**Beijing (Number:1)**
北京	Beijing
天津6个	**Tianjin(Number:6)**
天津	Tianjin
西青	Xiqing
武清	Wuqing
天津子牙	Tianjinziya
东丽	Dongli
北辰	Beichen
河北6个	**Hebei(Number:6)**
秦皇岛	Qinhuangdao
廊坊	Langfang
沧州临港	Cangzhoulingang
石家庄	Shijiazhuang
唐山曹妃甸	Tangshancaofeidian
邯郸	Handan
山西4个	**Shanxi(Number:4)**
太原	Taiyuan
大同	Datong
晋中	Jinzhong
晋城	Jincheng
内蒙古3个	**Inner Mongolia (Number:3)**
呼和浩特	Huhehaote
巴彦淖尔	Bayannaoer
呼伦贝尔	Hulunbeier
辽宁9个	**Liaoning (Number:9)**
大连	Dalian
营口	Yingkou
沈阳	Shenyang
铁岭	Tieling
大连长兴岛	Dalianchangxingdao
锦州	Jinzhou
盘锦辽滨沿海	Panjinliaobinyanhai
沈阳辉山	Shenyanghuishan
旅顺	Lvshun
吉林5个	**Jilin (Number:5)**
长春	Changchun
吉林	Jilin
四平红嘴	Sipinghongzui
长春汽车	Changchunqiche
松原	Songyuan
黑龙江8个	**Heilongjiang (Number:8)**
哈尔滨	Haerbin
宾西	Binxi
海林	Hailin
哈尔滨利民	Haerbinlimin
大庆	Daqing
绥化	Suihua
牡丹江	Mudanjiang

双鸭山	Shuangyashan
上海6个	**Shanghai (Number:6)**
闵行	Minhang
虹桥	Hongqiao
上海漕河泾新兴	Shanghaicaohejingxinxing
上海金桥出口加工区	Shanghaijinqiaochukoujiagongqu
上海化学工业	Shanghaihuaxuegongye
松江	Songjiang
江苏25个	**Jiangsu (Number:25)**
南通	Nantong
连云港	Lianyungang
昆山	Kunshan
苏州工业园区	Suzhougongyeyuanqu
南京	Nanjing
扬州	Yangzhou
徐州	Xuzhou
镇江	Zhenjiang
吴江	Wujiang
江宁	Jiangning
常熟	Changshu
淮安	Huaian
盐城	Yancheng
锡山	Xishan
太仓港	Taicanggang
张家港	Zhangjiagang
海安	Haian
靖江	Jingjiang
吴中	Wuzhong
宿迁	Suqian
海门	Haimen
如皋	Rugao
宜兴	Yixing
浒墅关	Hushuguan
沭阳	Shuyang
浙江20个	**Zhejiang (Number:20)**
宁波	Ningbo
温州	Wenzhou
宁波大榭开发区	Ningbodaxie
杭州	Hangzhou
萧山	Xiaoshan
嘉兴	Jiaxing
湖州	Huzhou
绍兴袍江	Shaoxingpaojiang
金华	Jinhua
长兴	Changxing
宁波石化	Ningboshihua
嘉善	Jiashan
衢州	Quzhou
义乌	Yiwu

杭州余杭	Hangzhouyuhang
富阳	Fuyang
绍兴柯桥	Shaoxingkeqiao
平湖	Pinghu
杭州湾上虞	Hangzhouwanshangyu
慈溪	Cixi
安徽11个	**Anhui (Number:11)**
芜湖	Wuhu
合肥	Hefei
马鞍山	Maanshan
安庆	Anqing
铜陵	Tongling
滁州	Chuzhou
池州	Chizhou
六安	Liuan
淮南	Huainan
宁国	Ningguo
桐城	Tongcheng
福建10个	**Fujian (Number:10)**
福州	Fuzhou
厦门海沧台商投资区	Xiamenhaicangtaishangtouziqu
福清融侨	Fuqingrongqiao
东山	Dongshan
漳州招商局	Zhangzhouzhaoshangju
泉州	Quanzhou
漳州台商投资区	Zhangzhoutaishangtouziqu
泉州台商投资区	Quanzhoutaishangtouziqu
龙岩	Longyan
东侨	Dongqiao
江西10个	**Jiangxi (Number:10)**
南昌	Nanchang
九江	Jiujiang
赣州	Ganzhou
井冈山	Jinggangshan
上饶	Shangrao
萍乡	Pingxiang
南昌小蓝	Nanchangxiaolan
宜春	Yichun
龙南	Longnan
瑞金	Ruijin
山东15个	**Shandong (Number:15)**
青岛	Qingdao
烟台	Yantai
威海	Weihai
东营	Dongying
日照	Rizhao
潍坊滨海	Weifangbinhai
邹平	Zouping
临沂	Linyi

招远	Zhaoyuan
德州	Dezhou
明水	Mingshui
胶州	Jiaozhou
聊城	Liaocheng
滨州	Binzhou
威海临港	Weihailingang
河南9个	**Henan (Number:9)**
郑州	Zhengzhou
漯河	Luohe
鹤壁	Hebi
开封	Kaifeng
许昌	Xuchang
洛阳	Luoyang
新乡	Xinxiang
红旗渠	Hongqiqu
濮阳	Puyang
湖北7个	**Hubei (Number:7)**
武汉	Wuhan
黄石	Huangshi
襄阳	Xiangyang
武汉临空港	Wuhanlinkonggang
荆州	Jingzhou
鄂州葛店	Ezhougedian
十堰	Shiyan
湖南8个	**Hunan (Number:8)**
长沙	Changsha
岳阳	Yueyang
常德	Changde
宁乡	Ningxiang
湘潭	Xiangtan
浏阳	Liuyang
娄底	Loudi
望城	Wangcheng
广东6个	Guangdong
湛江	Zhanjiang
广州	Guangzhou
广州南沙	Guangzhounansha
惠州大亚湾	Huizhoudayawan
增城	Zengcheng
珠海	Zhuhai
广西4个	**Guangxi (Number:4)**
南宁	Nanning
钦州港	Qinzhougang
中国-马来西亚钦州产业园区	China-Malaysia qinzhou
广西-东盟	Guangxi-Dongmeng
海南1个	**Hainan(Number:1)**
海南洋浦经济开发区	Hainanyangpujingjikaifaqu
重庆3个	**Chongqing(Number:3)**

重庆	chongqing
万州	Wanzhou
长寿	Changshou
四川8个	**Sichuan(Number:8)**
成都	Chengdu
广安	Guangan
德阳	Deyang
遂宁	Suining
绵阳	Mianyang
广元	Guangyuan
宜宾临港	Yibinlingang
内江	Neijiang
贵州2个	**Guizhou(Number:2)**
贵阳	Guiyang
遵义	Zunyi
云南5个	**Yunnan(Number:5)**
昆明	Kunming
曲靖	Qujing
蒙自	Mengzi
嵩明杨林	Songmingyanglin
大理	Dali
西藏1个	**Xicang(Number:1)**
拉萨	Lasa
陕西5个	**Shaanxi(Number:5)**
西安	Xian
陕西航空	Shanxihangkong
陕西航天	Shanxihangtian
汉中	Hanzhong
神府	Shenfu
甘肃5个	**Gansu(Number:5)**
兰州	Lanzhou
金昌	Jinchang
天水	Tianshui
酒泉	Jiuquan
张掖	Zhangye
青海2个	**Qinghai(Number:2)**
西宁	Xining
格尔木昆仑	Geermukunlun
宁夏2个	**Ningxia(Number:2)**
银川	Yinchuan
石嘴山	Shizuishan
新疆8个	**Xinjiang(Number:8)**
乌鲁木齐	Wulumuqi
石河子	Shihezi
库尔勒	Kuerle
五家渠	Wujiaqu
奎屯	Kuitun
阿拉尔	Alaer
准东	Zhundong

甘泉堡	Ganquanbao

All exports of Primary aluminium from July 2008 to June 2014				
CN Code	**Description**	**Period**	**Volume (Ton)**	**Value (Ten thousands dollar)**
76011010	Primary aluminium	July 2008-June 2014	23,678.6	7,354.6
76011090			708,394.8	157,618.6
Total of primary aluminium			732,073.4	164,973.2

All imports of Primary aluminium from July 2008 to June 2014				
CN Code	**Description**	**Month**	**Volume (Ton)**	**Value (Ten thousands dollar)**
76011010	Primary aluminium	July 2008-June 2014	35,328.9	8,577.3
76011090			3,092,725.1	576,428.7
Total			3,128,054.0	585,006.0

Enterprise Income Tax Law of the People’s Republic of China

(Adopted at the 5th Session of the 10th National People’s Congress of the People’s Republic of China on March 16, 2007)

Contents

Chapter I General Provisions

Article 1 Within the territory of the People’s Republic of China, the enterprises and other organizations that have incomes (hereinafter referred to as the enterprises) shall be payers of the enterprise income tax and shall pay their enterprise income taxes in accordance with this Law.

This Law does not apply to the sole individual proprietorship enterprises and partnership enterprises.

Article 2 Enterprises are classified into resident and non-resident enterprises.

The term "resident enterprise" as mentioned in this Law refers to an enterprise that is established inside China, or which is established under the law of a foreign country (region) but whose actual office of management is inside China.

The term "non-resident enterprise" as mentioned in this Law refers to an enterprise established under the law of a foreign country (region) , whose actual institution of management is not inside China but which has offices or establishments inside China; or which does not have any offices or establishments inside China but has incomes sourced in China.

Article 3 A resident enterprise shall pay the enterprise income tax on its incomes derived from both inside and outside China.

For a non-resident enterprise having offices or establishments inside China, it shall pay enterprise income tax on its incomes derived from China as well as on incomes that it earns outside China but which has real connection with the said offices or establishments.

For a non-resident enterprise having no office or establishment inside China, or for a non-resident enterprise whose incomes have no actual connection to its institution or establishment inside China, it shall pay enterprise income tax on the incomes derived from China.

Article 4 The enterprise income tax rate shall be 25%.

The tax rate that applies to a non-resident enterprise's incomes as mentioned in paragraph 3, Article 3 of this Law shall be 20%.

Chapter II Taxable Amount of Income

Article 5 The balance after deducting the tax-free incomes, tax-exempt incomes, all deduction items as well as the permitted remedies for losses of the previous year(s) from an enterprise's total amount of incomes of each tax year shall be the taxable amount of incomes.

Article 6 An enterprise's monetary and non-monetary incomes from various sources shall be the total amount of incomes, including:

(1) income from the sale of goods;

(2) income from the provision of labor services;

(3) income from the transaction of property;

(4) dividend, bonus and other equity investment proceeds;

(5) income from interests;

(6) income from rentals;

(7) income from royalties;

(8) income from accepted donations; and

(9) other incomes.

Article 7 The following incomes included in the total amount of incomes shall be tax-free incomes:

(1) The appropriations from the treasury;

(2) The administrative fees and the governmental funds that are charged according to the law and fall under the treasury administration; and

(3) Other tax-free incomes as prescribed by the State Council.

Article 8 The reasonable disbursements that are actually incurred and in which have actual connection with the business operations of an enterprise, including the costs, expenses, taxes, losses, etc., may be deducted in the calculation of the taxable amount of incomes.

Article 9 With regard to an enterprise’s disbursements for public welfare donations, the portion that accounts for 12% of the total annual profits or less is allowed to be deducted.

Article 10 None of the following disbursements may be deducted in the calculation of the taxable amount of incomes:

(1) Dividend, bonus and other equity investment proceeds paid to the investors;

(2) Payment for enterprise income tax;

(3) Late fee for taxes;

(4) Pecuniary punishment, fines, and losses of properties confiscated;

(5) Disbursements for donations other than those provided for in Article 9;

(6) Sponsorship disbursements;

(7) Unverified reserve disbursements;

(8) Other disbursements that have nothing to do with the obtainment of revenues;

Article 11 When calculating the taxable amount of incomes, an enterprise is allowed to deduct the depreciations of fixed assets calculated under the relevant provisions.

No depreciation may be calculated for any of the following fixed assets:

(1) The fixed assets that have not yet been put into use, excluding houses and buildings;

(2) The fixed assets rented in by way of commercial lease;

(3) The fixed assets rented out by way of finance leasing;

(4) The fixed assets for which depreciation has been allocated in full amount but which remain in use;

(5) The fixed assets that have nothing to do with the business operations;

(6) The land that is separately appraised and entered into account as an item of fixed asset; and

(7) Other fixed assets for which no depreciation may be calculated.

Article 12 When calculating the taxable amount of incomes, an enterprise is allowed to deduct the amortized expenses of intangible assets calculated according to the relevant provisions.

No amortized expense may be calculated for the following intangible assets:

(1) The intangible assets, for which the self-development expenses have been deducted in the calculation of the taxable amount of incomes;

(2) The self-created business reputation;

(3) The intangible assets that have nothing to do with the business operations; and

(4) Other intangible assets for which no amortized expense may be calculated.

Article 13 The following expenses incurred by an enterprise shall, in the calculation of the taxable amount of incomes, be treated as long-term deferred expenses. Those amortized under the relevant provisions are allowed to be deducted:

(1) The expenses for the rebuilding of a fixed asset, for which depreciation has been prepared in full amount;

(2) The expenses for the rebuilding of a rented fixed asset;

(3) The expenses for the heavy repair of a fixed asset; and

(4) Other expenses that shall be treated as long-term deferred expenses.

Article 14 During the period of external investment, an enterprise shall not deduct the costs of the investment assets when it calculates the taxable amount of incomes.

Article 15 Where an enterprise uses or sells its inventories, it is allowed to deduct the costs of the inventories calculated according to the relevant provisions in the calculation of the taxable amount of incomes.

Article 16 Where an enterprise transfers an asset, it is allowed to deduct the net value of the asset in the calculation of the taxable amount of incomes.

Article 17 When an enterprise calculates its enterprise income taxes on a consolidated basis, it shall not offset the losses of its overseas business institutions against the profits of its domestic business institutions.

Article 18 The losses incurred by an enterprise during a tax year may be carried forward and subtracted from the incomes during subsequent years for a maximum carry-forward period of 5 years.

Article 19 Where a non-resident enterprise obtains incomes as described in paragraph 3, Article 3 of this Law, it shall calculate the taxable amount of income through following approaches:

(1) The taxable amount of incomes from dividends, bonuses and other equity investment proceeds, interests, rentals and royalties shall be based on the total amount of incomes;

(2) The taxable amount of incomes from the assignment of property shall be the balance of the total amount of incomes less the net value of the property; and

(3) The taxable amount of any other income shall be calculated by reference to the approaches as mentioned in the preceding items.

Article 20 The specific measures for the scope and criterions of revenues and deductions, as well as the tax treatment of assets as provided for in the present Chapter shall be formulated by the treasury and tax administrative departments of the State Council.

Article 21 When calculating the taxable amount of incomes, if the enterprise's financial or accounting treatment method does not conform to any tax law or administrative regulation, the taxable amount shall be calculated in accordance with the tax law or administrative regulation.

Chapter III Amount of Payable Taxes

Article 22 The amount of payable taxes shall be the balance of the taxable amount multiplied by the applicable tax rate minus the tax amounts deducted and exempted as provided for in this Law.

Article 23 An enterprise may deduct from the taxable amount of incomes of the current period the amount of income tax that the enterprise has already paid overseas for the following incomes. The limit of tax credit shall be the payable amount of taxes on such incomes computed according to this Law. The portion exceeding the limit of tax credit may, during the five subsequent years, be offset by way of deducting the limit of tax credit of each year from the balance after the deduction of the limit of tax credit of the current year:

(1) A resident enterprise's taxable incomes derived outside China; and

(2) Taxable incomes earned outside China by a non-resident enterprise having offices or establishments in China, but which have no actual connection with the said offcies or establishments.

Article 24 For the dividends, bonuses and other equity investment proceeds derived outside China, which a resident enterprise obtains from its directly or indirectly controlled foreign enterprise, the portion of income tax on this income paid by the foreign enterprise outside China may be treated as the allowable tax credit of overseas income tax amount of the resident enterprise and be deducted within the limit of tax credit as prescribed in Article 23 of this Law.

Chapter IV Preferential Tax Treatments

Article 25 Preferential in enterprise income tax treatments are granted to the important industries and projects whose development is supported and encouraged by the state.

Article 26 The following incomes of an enterprise shall be tax-free incomes:

(1) The income from treasury bonds;

(2) Dividends, bonuses and other equity investment proceeds distributed between qualified resident enterprises;

(3) Dividends, bonuses and other equity investment proceeds that a non-resident enterprise with institutions or establishments in China obtains from a resident enterprise and which have actual connection with such institutions or establishments; and

(4) Incomes of qualified not-for-profit organizations.

Article 27 The enterprise income tax on the following incomes may be exempted or reduced:

(1) The incomes incurred from projects of agriculture, forestry, husbandry and fishery;

(2) The incomes incurred from business operations of the important public infrastructure investment projects supported by the state;

(3) The income incurred from the projects of environmental protection, energy and water saving, which meet the relevant requirements;

(4) The incomes incurred from the transfer of technologies, which meets the relevant requirements; and

(5) The income as prescribed in paragraph 3, Article 3 of this Law.

Article 28 The enterprise income tax on a small meagre-profit enterprise that meets the prescribed conditions shall be levied at a reduced tax rate of 20%.

The enterprise income tax on important high- and new-tech enterprises that are necessary to be supported by the state shall be levied at the reduced tax rate of 15%.

Article 29 The autonomous organ of an autonomous region of ethnic minorities may decide the reduction or exemption of the local portion of the enterprise income tax to be paid by enterprises within the said autonomous region. The decisions of deduction or exemption made an autonomous prefecture or county shall be submitted to the people's government of the province, autonomous region, or municipality directly under the Central Government for approval.

Article 30 The following expenses of an enterprise may be additionally calculated and deducted:

(1) The expenses for the research and development of new technologies, new products and new techniques; and

(2) The wages paid to the disabled employees or other employees whom the state encourages to hire.

Article 31 A startup investment enterprise engaged in important startup investments that are necessary to be supported and encouraged by the state may deduct from the taxable amount of incomes a certain proportion of the amount of investment.

Article 32 Where it is surely necessary to accelerate the depreciation of any fixed asset of an enterprise because of technological progress or due to any other cause, it may shorten the term of depreciation or adopt an approach to accelerate the depreciation.

Article 33 The incomes generated by an enterprise from producing products conforming to the industrial policies of the state in the way of comprehensive utilization of resources may be downsized in the calculation of the amount of taxable incomes.

Article 34 The amount of an enterprise's investment in the purchase of special equipment for environmental protection, energy and water saving, work safety, etc. may be deducted from the tax amount at a certain rate.

Article 35 The specific measures for the preferential tax treatments as mentioned in this Law shall be formulated by the State Council.

Article 36 Where the national economic and social development so requires, or the business operations of enterprises have been seriously affected by emergencies and other factors, the State Council may formulate special preferential policies concerning the enterprise income tax and submitted them to the Standing Committee of the National People's Congress for archival purposes.

Chapter V Withholding by Income Sources

Article 37 The payable income taxes on the incomes as described in paragraph 3, Article 3 of this Law that a non-resident enterprise earns shall be withheld by income sources, with the payer acting as the obligatory withholder. The tax amount shall be withheld by the obligatory withholder from each payment or payment due.

Article 38 For the payable income taxes on the incomes that a non-resident enterprise obtains from undertaking an engineering project or providing labor services inside China, the tax organ may designate the payer of the project price or remuneration as the obligatory withholder.

Article 39 For the income tax that shall be withheld under Articles 37 and 38 of this Law but the obligatory withholder has failed to withhold or is unable to perform the withholding obligation, the taxpayer shall pay them at the place where the income has occurred. If the taxpayer fails to do so, the tax organ may recover the payable tax of the enterprise from its other income items inside China for which the payer should pay.

Article 40 An obligatory withholder shall turn over the withheld taxes to the state treasury within 7 days after the date of withholding and submit to the local tax organ a form of report on the withheld enterprise income taxes.

Chapter VI Special Adjustments to Tax Payments

Article 41 With regard to a transaction between an enterprise and its affiliate, if the taxable revenue or income of the enterprise or its affiliate decreases due to inconformity with the arms length principle, the tax organ may make an adjustment through a reasonable method.

The costs of an enterprise and its affiliate for joint development or accepting the assignment of intangible assets, or jointly providing or accepting labor services shall, according to the arms length principle, be apportioned in the calculation of the taxable amount of incomes.

Article 42 An enterprise may file with the tax organ the pricing principles and computation approaches for the transactions between it and its affiliates, the tax organ and the enterprise shall enter into an advance pricing arrangement upon negotiations and confirmation.

Article 43 When an enterprise submits to the tax organ its annual enterprise income tax returns, the enterprise shall enclose an annual report on the related transactions with its affiliates.

When the tax organ investigates into the affiliated transactions, the enterprise and its affiliates, as well as other enterprises relating to the affiliated transactions under investigation, shall provide the pertinent materials according to the relevant provisions.

Article 44 Where any enterprise refuses to provide the materials of transactions with its affiliates, or provides any false or incomplete materials that cannot reflect the true information about the affiliated transactions, the tax organ may decide a taxable income after an investigation.

Article 45 With regard to an enterprise that is established by a resident enterprise, controlled by a resident enterprise, or by a Chinese resident who is located in a country (region) where the actual tax burden is obviously lower than the tax rate as prescribed in paragraph 1 of Article 4 of this Law, if the profits are not distributed or are distributed partially for a cause that is not a reasonable business operation, the portion of the aforesaid profits attributable to this resident enterprise shall be included in its incomes of the current period.

Article 46 The interest disbursement for any debt investments and equity investments, which an enterprise accepts from its affiliates, in excess of the prescribed criterion shall not be deducted in the calculation of the taxable amount of income.

Article 47 Where an enterprise makes any other arrangement not for any reasonable business purpose, if its taxable revenue or income decreases, the tax organ has the power to make an adjustment through a reasonable method.

Article 48 If the tax organ makes an adjustment to a tax payment under the provisions of this Chapter and if it is necessary to recover the tax payment in arrears, it shall do so and charge an additional interest under the provisions of the State Council.

Chapter VII Administration of Tax Collection

Article 49 The administration of the collection of enterprise income taxes shall be governed by the Law of the People’s Republic of China on the Administration of Tax Collection in addition to this Law.

Article 50 Unless it is otherwise provided for in any tax law or administrative regulation, the tax payment place of a resident enterprise shall be the registration place of the said enterprise. But if its registration place is outside China, the tax payment place shall be the place where its office of actual management is located.

A resident enterprise that has established an operational institution that has no legal person status in China shall calculate and pay its enterprise income taxes on a consolidated basis.

Article 51 Where a non-resident enterprise obtains any income as described in paragraph 2, Article 3 of this Law, the tax payment place shall be the place where the institution or establishment is located. Where a non-resident enterprise has established two or more institutions or establishments within China, it may, subject to the examination and approval of the tax organ, choose to have its main institution or establishment pay the enterprise income tax on a consolidated basis.

For a non-resident enterprise that obtains any income as described in paragraph 3, Article 3 of this Law, the place where the obligatory withholder is located shall be the place for the payment of enterprise income taxes.

Article 52 Unless it is otherwise provided for by the State Council, enterprises shall not pay their enterprise income taxes on a consolidated basis.

Article 53 Enterprise income taxes shall be calculated on the basis of a tax year. A tax year commences on January 1 and ends on December 31 of the Gregorian calendar year.

Where an enterprise starts or terminates its business operations in the middle of a tax year so that its actual business operation period in this tax year is shorter than 12 months, its actual business operation period shall constitute its tax year.

At the time of liquidation of an enterprise, the liquidation period shall be the tax year for the enterprise.

Article 54 Enterprise income taxes shall be paid in advance on the monthly or quarterly basis.

An enterprise shall, within 15 days after the end of a month or quarter, submit to the tax organ an enterprise income tax return for advance payment and pay the tax in advance.

An enterprise shall, within 5 months after the end of each year, submit to the tax organ an annual enterprise income tax return for the settlement of tax payments and settle the payable or refundable amount of taxes.

When an enterprise submits an enterprise income tax return, it shall attach to it the financial statements and other relevant materials according to the relevant provisions.

Article 55 When an enterprise terminates its business operation in the middle of a year, it shall, within 60 days after the actual date of termination of its business operations, apply to the tax organ for calculating and paying the enterprise income taxes of the current period.

Before an enterprise goes through the deregistration formalities, it shall make a declaration to the tax organ on the liquidation and shall pay the enterprise income taxes.

Article 56 Enterprise income taxes to be paid under this law shall be calculated on the basis of RMB. For any income calculated on the basis of a currency other than RMB, the amount of taxes shall be calculated and paid after this income is converted into RMB.

Chapter VIII Supplementary Provisions

Article 57 For the enterprises that were established prior to the promulgation of this Law and enjoyed lower tax rates according to the provisions of the previous tax laws and administrative regulations, their income tax rates shall, according to the provisions of the State Council, be gradually transferred to the tax rate provided in this Law within five years after this Law is promulgated. The enterprises that have enjoyed the preferential treatment of tax exemption for a fixed term may, according to the provisions of the State Council, continue to enjoy such treatment after the promulgation of this Law until the fix term expires. However, for those that have failed to enjoy the preferential treatment due to failure to make profits, the term of preferential treatment may be counted as of the year when this Law is promulgated.

The high- and new-tech enterprises that need the key support of the state newly established in the particular areas established by law for developing foreign economic cooperation and technological exchanges or in the areas where the State Council has provided for the implementation of the abovementioned special policies may continue to enjoy transitional preferential tax treatments, according to the specific measures to be formulated by the State Council.

Other enterprises falling in the encouraged category as already determined by the State Council may enjoy the preferential treatment of tax reduction or exemption according to the provisions of the State Council.

Article 58 Where any provision in a tax treaty concluded between the government of the People’s Republic of China and a foreign government is different from the provisions in this Law, the provision in the treaty shall prevail.

Article 59 The State Council shall formulate a regulation on the implementation of this Law.

Article 60 This law shall come into force as of August 1, 2008. The Income Tax Law of the People’s Republic of China on Foreign-funded Enterprises and Foreign Enterprises adopted at the 4th Session of the Standing Committee of the 7th National People’s Congress on April 9, 1991 and the Interim Regulation of the People’s Republic of China on Enterprise Income Tax promulgated by the State Council on December 13, 1993 shall be repealed simultaneously.

中华人民共和国企业所得税法

（2007 年 3 月 16 日第十届全国人民代表大会第五次会议通过）

目录

第一章　总则

第一条　在中华人民共和国境内，企业和其他取得收入的组织（以下统称企业）为企业所得税的纳税人，依照本法的规定缴纳企业所得税。

个人独资企业、合伙企业不适用本法。

第二条　企业分为居民企业和非居民企业。

本法所称居民企业，是指依法在中国境内成立，或者依照外国（地区）法律成立但实际管理机构在中国境内的企业。

本法所称非居民企业，是指依照外国（地区）法律成立且实际管理机构不在中国境内，但在中国境内设立机构、场所的，或者在中国境内未设立机构、场所，但有来源于中国境内所得的企业。

第三条　居民企业应当就其来源于中国境内、境外的所得缴纳企业所得税。

非居民企业在中国境内设立机构、场所的，应当就其所设机构、场所取得的来源于中国境内的所得，以及发生在中国境外但与其所设机构、场所有实际联系的所得，缴纳企业所得税。

非居民企业在中国境内未设立机构、场所的，或者虽设立机构、场所但取得的所得与其所设机构、场所没有实际联系的，应当就其来源于中国境内的所得缴纳企业所得税。

第四条　企业所得税的税率为 25%。

非居民企业取得本法第三条第三款规定的所得，适用税率为20%。

第二章　应纳税所得额

第五条　企业每一纳税年度的收入总额，减除不征税收入、免税收入、各项扣除以及允许弥补的以前年度亏损后的余额，为应纳税所得额。

第六条　企业以货币形式和非货币形式从各种来源取得的收入，为收入总额。包括：

（一）销售货物收入；

（二）提供劳务收入；

（三）转让财产收入；

（四）股息、红利等权益性投资收益；

（五）利息收入；

（六）租金收入；

（七）特许权使用费收入；

（八）接受捐赠收入；

（九）其他收入。

第七条　收入总额中的下列收入为不征税收入：

（一）财政拨款；

（二）依法收取并纳入财政管理的行政事业性收费、政府性基金；

（三）国务院规定的其他不征税收入。

第八条　企业实际发生的与取得收入有关的、合理的支出，包括成本、费用、税金、损失和其他支出，准予在计算应纳税所得额时扣除。

第九条　企业发生的公益性捐赠支出，在年度利润总额12%以内的部分，准予在计算应纳税所得额时扣除。

第十条　在计算应纳税所得额时，下列支出不得扣除：

（一）向投资者支付的股息、红利等权益性投资收益款项；

（二）企业所得税税款；

（三）税收滞纳金；

（四）罚金、罚款和被没收财物的损失；

（五）本法第九条规定以外的捐赠支出；

（六）赞助支出；

（七）未经核定的准备金支出；

（八）与取得收入无关的其他支出。

第十一条　在计算应纳税所得额时，企业按照规定计算的固定资产折旧，准予扣除。

下列固定资产不得计算折旧扣除：

（一）房屋、建筑物以外未投入使用的固定资产；

（二）以经营租赁方式租入的固定资产；

（三）以融资租赁方式租出的固定资产；

（四）已足额提取折旧仍继续使用的固定资产；

（五）与经营活动无关的固定资产；

（六）单独估价作为固定资产入账的土地；

（七）其他不得计算折旧扣除的固定资产。

第十二条　在计算应纳税所得额时，企业按照规定计算的无形资产摊销费用，准予扣除。

下列无形资产不得计算摊销费用扣除：

（一）自行开发的支出已在计算应纳税所得额时扣除的无形资产；

（二）自创商誉；

（三）与经营活动无关的无形资产；

（四）其他不得计算摊销费用扣除的无形资产。

第十三条　在计算应纳税所得额时，企业发生的下列支出作为长期待摊费用，按照规定摊销的，准予扣除：

（一）已足额提取折旧的固定资产的改建支出；

（二）租入固定资产的改建支出；

（三）固定资产的大修理支出；

（四）其他应当作为长期待摊费用的支出。

第十四条　企业对外投资期间，投资资产的成本在计算应纳税所得额时不得扣除。

第十五条　企业使用或者销售存货，按照规定计算的存货成本，准予在计算应纳税所得额时扣除。

第十六条　企业转让资产，该项资产的净值，准予在计算应纳税所得额时扣除。

第十七条　企业在汇总计算缴纳企业所得税时，其境外营业机构的亏损不得抵减境内营业机构的盈利。

第十八条　企业纳税年度发生的亏损，准予向以后年度结转，用以后年度的所得弥补，但结转年限最长不得超过五年。

第十九条　非居民企业取得本法第三条第三款规定的所得，按照下列方法计算其应纳税所得额：

（一）股息、红利等权益性投资收益和利息、租金、特许权使用费所得，以收入全额为应纳税所得额；

（二）转让财产所得，以收入全额减除财产净值后的余额为应纳税所得额；

（三）其他所得，参照前两项规定的方法计算应纳税所得额。

第二十条　本章规定的收入、扣除的具体范围、标准和资产的税务处理的具体办法，由国务院财政、税务主管部门规定。

第二十一条　在计算应纳税所得额时，企业财务、会计处理办法与税收法律、行政法规的规定不一致的，应当依照税收法律、行政法规的规定计算。

第三章　应纳税额

第二十二条　企业的应纳税所得额乘以适用税率，减除依照本法关于税收优惠的规定减免和抵免的税额后的余额，为应纳税额。

第二十三条　企业取得的下列所得已在境外缴纳的所得税税额，可以从其当期应纳税额中抵免，抵免限额为该项所得依照本法规定计算的应纳税额；超过抵免限额的部分，可以在以后五个年度内，用每年度抵免限额抵免当年应抵税额后的余额进行抵补：

（一）居民企业来源于中国境外的应税所得；

（二）非居民企业在中国境内设立机构、场所，取得发生在中国境外但与该机构、场所有实际联系的应税所得。

第二十四条　居民企业从其直接或者间接控制的外国企业分得的来源于中国境外的股息、红利等权益性投资收益，外国企业在境外实际缴纳的所得税税额中属于该项所得负担的部分，可以作为该居民企业的可抵免境外所得税税额，在本法第二十三条规定的抵免限额内抵免。

第四章　税收优惠

第二十五条　国家对重点扶持和鼓励发展的产业和项目，给予企业所得税优惠。

第二十六条　企业的下列收入为免税收入：

（一）国债利息收入；

（二）符合条件的居民企业之间的股息、红利等权益性投资收益；

（三）在中国境内设立机构、场所的非居民企业从居民企业取得与该机构、场所有实际联系的股息、红利等权益性投资收益；

（四）符合条件的非营利组织的收入。

第二十七条　企业的下列所得，可以免征、减征企业所得税：

（一）从事农、林、牧、渔业项目的所得；

（二）从事国家重点扶持的公共基础设施项目投资经营的所得；

（三）从事符合条件的环境保护、节能节水项目的所得；

（四）符合条件的技术转让所得；

（五）本法第三条第三款规定的所得。

第二十八条　符合条件的小型微利企业，减按20%的税率征收企业所得税。

国家需要重点扶持的高新技术企业，减按15％的税率征收企业所得税。

第二十九条　民族自治地方的自治机关对本民族自治地方的企业应缴纳的企业所得税中属于地方分享的部分，可以决定减征或者免征。自治州、自治县决定减征或者免征的，须报省、自治区、直辖市人民政府批准。

第三十条　企业的下列支出，可以在计算应纳税所得额时加计扣除：

（一）开发新技术、新产品、新工艺发生的研究开发费用；

（二）安置残疾人员及国家鼓励安置的其他就业人员所支付的工资。

第三十一条　创业投资企业从事国家需要重点扶持和鼓励的创业投资，可以按投资额的一定比例抵扣应纳税所得额。

第三十二条　企业的固定资产由于技术进步等原因，确需加速折旧的，可以缩短折旧年限或者采取加速折旧的方法。

第三十三条　企业综合利用资源，生产符合国家产业政策规定的产品所取得的收入，可以在计算应纳税所得额时减计收入。

第三十四条　企业购置用于环境保护、节能节水、安全生产等专用设备的投资额，可以按一定比例实行税额抵免。

第三十五条　本法规定的税收优惠的具体办法，由国务院规定。

第三十六条　根据国民经济和社会发展的需要，或者由于突发事件等原因对企业经营活动产生重大影响的，国务院可以制定企业所得税专项优惠政策，报全国人民代表大会常务委员会备案。

第五章　源泉扣缴

第三十七条　对非居民企业取得本法第三条第三款规定的所得应缴纳的所得税，实行源泉扣缴，以支付人为扣缴义务人。税款由扣缴义务人在每次支付或者到期应支付时，从支付或者到期应支付的款项中扣缴。

第三十八条　对非居民企业在中国境内取得工程作业和劳务所得应缴纳的所得税，税务机关可以指定工程价款或者劳务费的支付人为扣缴义务人。

第三十九条　依照本法第三十七条、第三十八条规定应当扣缴的所得税，扣缴义务人未依法扣缴或者无法履行扣缴义务的，由纳税人在所得发生地缴纳。纳税人未依法缴纳的，税务机关可以从该纳税人在中国境内其他收入项目的支付人应付的款项中，追缴该纳税人的应纳税款。

第四十条　扣缴义务人每次代扣的税款，应当自代扣之日起七日内缴入国库，并向所在地的税务机关报送扣缴企业所得税报告表。

第六章　特别纳税调整

第四十一条　企业与其关联方之间的业务往来，不符合独立交易原则而减少企业或者其关联方应纳税收入或者所得额的，税务机关有权按照合理方法调整。

企业与其关联方共同开发、受让无形资产，或者共同提供、接受劳务发生的成本，在计算应纳税所得额时应当按照独立交易原则进行分摊。

第四十二条　企业可以向税务机关提出与其关联方之间业务往来的定价原则和计算方法，税务机关与企业协商、确认后，达成预约定价安排。

第四十三条　企业向税务机关报送年度企业所得税纳税申报表时，应当就其与关联方之间的业务往来，附送年度关联业务往来报告表。

税务机关在进行关联业务调查时，企业及其关联方，以及与关联业务调查有关的其他企业，应当按照规定提供相关资料。

第四十四条　企业不提供与其关联方之间业务往来资料，或者提供虚假、不完整资料，未能真实反映其关联业务往来情况的，税务机关有权依法核定其应纳税所得额。

第四十五条　由居民企业，或者由居民企业和中国居民控制的设立在实际税负明显低于本法第四条第一款规定税率水平的国家（地区）的企业，并非由于合理的经营需要而对利润不作分配或者减少分配的，上述利润中应归属于该居民企业的部分，应当计入该居民企业的当期收入。

第四十六条　企业从其关联方接受的债权性投资与权益性投资的比例超过规定标准而发生的利息支出，不得在计算应纳税所得额时扣除。

第四十七条　企业实施其他不具有合理商业目的的安排而减少其应纳税收入或者所得额的，税务机关有权按照合理方法调整。

第四十八条　税务机关依照本章规定作出纳税调整，需要补征税款的，应当补征税款，并按照国务院规定加收利息。

第七章　征收管理

第四十九条　企业所得税的征收管理除本法规定外，依照《中华人民共和国税收征收管理法》的规定执行。

第五十条　除税收法律、行政法规另有规定外，居民企业以企业登记注册地为纳税地点；但登记注册地在境外的，以实际管理机构所在地为纳税地点。

居民企业在中国境内设立不具有法人资格的营业机构的，应当汇总计算并缴纳企业所得税。

第五十一条　非居民企业取得本法第三条第二款规定的所得，以机构、场所所在地为纳税地点。非居民企业在中国境内设立两个或者两个以上机构、场所的，经税务机关审核批准，可以选择由其主要机构、场所汇总缴纳企业所得税。

非居民企业取得本法第三条第三款规定的所得，以扣缴义务人所在地为纳税地点。

第五十二条　除国务院另有规定外，企业之间不得合并缴纳企业所得税。

第五十三条　企业所得税按纳税年度计算。纳税年度自公历 1 月 1 日起至 12 月 31 日止。

企业在一个纳税年度中间开业，或者终止经营活动，使该纳税年度的实际经营期不足十二个月的，应当以其实际经营期为一个纳税年度。

企业依法清算时，应当以清算期间作为一个纳税年度。

第五十四条　企业所得税分月或者分季预缴。

企业应当自月份或者季度终了之日起十五日内，向税务机关报送预缴企业所得税纳税申报表，预缴税款。

企业应当自年度终了之日起五个月内，向税务机关报送年度企业所得税纳税申报表，并汇算清缴，结清应缴应退税款。

企业在报送企业所得税纳税申报表时，应当按照规定附送财务会计报告和其他有关资料。

第五十五条　企业在年度中间终止经营活动的，应当自实际经营终止之日起六十日内，向税务机关办理当期企业所得税汇算清缴。

企业应当在办理注销登记前，就其清算所得向税务机关申报并依法缴纳企业所得税。

第五十六条　依照本法缴纳的企业所得税，以人民币计算。所得以人民币以外的货币计算的，应当折合成人民币计算并缴纳税款。

第八章　附则

第五十七条　本法公布前已经批准设立的企业，依照当时的税收法律、行政法规规定，享受低税率优惠的，按照国务院规定，可以在本法施行后五年内，逐步过渡到本法规定的税率；享受定期减免税优惠的，按照国务院规定，可以在本法施行后继续享受到期满为止，但因未获利而尚未享受优惠的，优惠期限从本法施行年度起计算。

法律设置的发展对外经济合作和技术交流的特定地区内，以及国务院已规定执行上述地区特殊政策的地区内新设立的国家需要重点扶持的高新技术企业，可以享受过渡性税收优惠，具体办法由国务院规定。

国家已确定的其他鼓励类企业，可以按照国务院规定享受减免税优惠。

第五十八条　中华人民共和国政府同外国政府订立的有关税收的协定与本法有不同规定的，依照协定的规定办理。

第五十九条　国务院根据本法制定实施条例。

第六十条　本法自2008年1月1日起施行。1991年4月9日第七届全国人民代表大会第四次会议通过的《中华人民共和国外商投资企业和外国企业所得税法》和1993年12月13日国务院发布的《中华人民共和国企业所得税暂行条例》同时废止。