铜精矿化学分析方法

第18部分：砷、锑、铋、铅、锌、镍、镉、钴、铬、氧化铝、氧化镁、氧化钙含量的测定

电感耦合等离子体原子发射光谱法

编制说明

（预审稿）

北矿检测技术有限公司

2022.7.16

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编制说明

**一、工作简况**

1.1 方法概况

1.1.1 项目的必要性

随着铜量需求不断地增加，铜精矿产量也在不断增加，铜精矿产量增加意味着冶炼铜时产生的铜渣量也会增加。为减少铜渣造成的污染和资源的浪费，需要对铜渣进行回收和利用，铜渣是水泥主要原料，GB 31893-2015《水泥中水溶性铬（VI）的的限量及测定方法》于2015年颁布，2016年10月1日正式实施。标准中明确规定了水泥中水溶性铬（VI）的含量不大于10.00 mg/kg，水溶性铬（VI）对人体和生态环境非常有害。 铜精矿作为铜冶炼中铜渣的来源，其中铬含量的准确测定极其重要，它直接影响到铜渣的贸易和下游水泥产业的产品质量。

现在的铜原料中三氧化二铝的含量波动较大，为控制生产工艺，调整冶炼配料，指导生产，从而保证产品质量，原标准GB/T3884.17-2014三氧化二铝的分析方法，采用铬天青S胶束增溶光度法和沉淀分离-氟盐置换-Na2EDTA 滴定法，不同批次比色试剂灵敏度不一致，结果不稳定，滴定法碱熔分离，流程长，不利于冶炼生产快速测定。

拟修订《铜精矿化学分析方法 第18部分：砷、锑、铋、铅、锌、镍、镉、钴、氧化镁、氧化钙含量的测定 电感耦合等离子体原子发射光谱法》，增加样品碱熔前处理方式，用电感耦合等离子体原子发射光谱法测定铬和氧化铝量。能够实现铬和氧化铝的快速、准确、同时测定，对贸易结算和指导生产具有重要的现实性和必要性。

1.1.2 适用范围

本文件适用于铜精矿中砷、锑、铋、铅、锌、镍、镉、钴、铬、氧化铝、氧化镁、氧化钙含量的测定。测定范围见表1。

表 1 测定范围

|  |  |
| --- | --- |
| 元素或氧化物 | 质量分数/% |
| As | 0.01～4.50 |
| Sb | 0.01～0.70 |
| Bi | 0.01～0.80 |
| Pb | 0.10～6.00 |
| Zn | 0.02～4.50 |
| Ni | 0.01～0.70 |
| Cd | 0.003～0.40 |
| Co | 0.01～1.00 |
| Cr | 0.040~4.50 |
| Al2O3 | 0.40~8.50 |
| MgO | 0.05～6.00 |
| CaO | 0.20～6.00 |

1.1.3可行性

北矿检测技术有限公司为国家重有色金属质量监督检验中心、国家进出口商品检验有色金属认可实验室、中国有色金属工业重金属质检中心、科技成果检测鉴定国家级检测机构，在国内有色金属分析领域具有权威地位。公司拥有多台火焰原子吸收光谱仪、电感耦合等离子体原子发射光谱仪、电感耦合等离子体质谱仪，具备项目研究所需的仪器设备。标准起草人员多次参与有色行业标准的起草、验证等工作，具有丰富的方法研究经验。

本标准的建立对企业在后续生产及市场交易提供有力的指导。本标准在起草、调研中得到了江西铜业股份有限公司、铜陵有色金属集团控股有限公司、大冶有色设计研究院有限公司、中国有色桂林矿产地质研究院有限公司、安徽国家铜铅锌及制品质量监督检验中心、金隆铜业有限公司等企业的积极响应。

1.1.4 要解决的主要问题

目前国内尚无电感耦合等离子体原子发射光谱测定铜精矿中铬和氧化铝的的化学分析方法，导致贸易有争议时得不到快速的解决。修订标准中增加样品碱熔前处理方式，用电感耦合等离子体原子发射光谱法测定铬和氧化铝量。能够实现铬和氧化铝的快速、准确、同时测定，对贸易结算和指导生产具有重要的现实性和必要性。

1.2 任务来源

根据国家标准化管理委员会及工业和信息化部标准计划项目的安排要求，全国有色金属标准化技术委员会“关于印发《铜精矿化学分析方法第12部分：氟和氯含量的测定离子色谱法和电位滴定法》等3项国家标准任务落实会议纪要的通知”（有色标秘[2021]91号）及相关会议纪要的文件精神，确定《铜精矿化学分析方法 第18部分：砷、锑、铋、铅、锌、镍、镉、钴、铬、氧化铝、氧化镁、氧化钙含量的测定 电感耦合等离子体原子发射光谱法》修订由北矿检测技术有限公司负责起草。项目计划编号为工信厅科？

协助起草单位包括江西铜业股份有限公司、铜陵有色金属集团控股有限公司、大冶有色设计研究院有限公司、中国有色桂林矿产地质研究院有限公司、安徽国家铜铅锌及制品质量监督检验中心、金隆铜业有限公司、金川集团股份有限公司、郴州市产商品质量监督检验所、紫金铜业有限公司、昆明冶金研究院有限公司、浙江华友钴业股份有限公司、山西北方铜业有限公司、福建紫金矿冶测试技术有限公司、中国检验认证集团广西有限公司、国合通用（青岛）测试评价有限公司、山东恒邦冶炼股份有限公司、中国检验认证集团广东有限公司黄埔分公司、湖南有色金属研究院有限责任公司、黑龙江紫金铜业有限公司等。

1.3 本标准编制单位、起草人及所做工作

本标准由北矿检测技术有限公司负责起草，主要起草人为 ，主要负责本标准的方法制定、资料收集、技术参数的确定及标准条款的编写工作。

本部分参与起草单位包括江西铜业股份有限公司、铜陵有色金属集团控股有限公司、大冶有色设计研究院有限公司、中国有色桂林矿产地质研究院有限公司、安徽国家铜铅锌及制品质量监督检验中心、金隆铜业有限公司、金川集团股份有限公司、郴州市产商品质量监督检验所、紫金铜业有限公司、昆明冶金研究院有限公司、浙江华友钴业股份有限公司、山西北方铜业有限公司、福建紫金矿冶测试技术有限公司、中国检验认证集团广西有限公司、国合通用（青岛）测试评价有限公司、山东恒邦冶炼股份有限公司、中国检验认证集团广东有限公司黄埔分公司、湖南有色金属研究院有限责任公司、黑龙江紫金铜业有限公司等。参与起草人为：刘晓燕、张征莲、唐碧玉、顾菲菲、臧真娟、孙国娟、谢磊、肖刘萍、赖晓芳、罗舜、杨喆涵、谢柏华、高娟亚、黄树婷、冯国超、刘凯、陈瑞扬、邱敏敏、曾军、刘娟、陈宇、沈显丽等（需补充未署名的验证人员），主要负责本标准的验证工作。

1.4 主要工作过程

2021年10月27日～29日全国有色金属标准化技术委员会在江苏常州市召开有色金属标准工作会议，会议确定了标准制定的起草单位和参与验证单位，落实了标准计划项目的进度安排和分工。在此期间各验证单位进行实验后，对本标准的主要修改意见如下：

1）标准文本：建议在8.4.2.3 移取10 mL试液（8.4.2.2）后写明转入100 mL容量瓶中；在8.5工作曲线B：铬、氧化铝工作曲线的配制：表5中Cr、Al2O3浓度写反需调整。

试验报告：在8.4.2.2 将坩埚置于400mL烧杯中，加100mL水改为10 mL水，因定容体积为100mL（中国有色桂林矿产地质研究院有限公司）。采纳。

1. 试剂硼酸由优级纯改为分析纯（安徽国家铜铅锌及制品质量监督检验中心）。不采纳，优级纯的碱熔剂（碳酸钠+碳酸钾+硼酸）中铝的试剂空白会更好。
2. 试验数据处理公式中不扣试样空白，因为曲线计算中已扣空白（安徽国家铜铅锌及制品质量监督检验中心）。采纳，调整为曲线计算中不扣空白。
3. 铝含量较低时（0.2μg/mL），Fe、Ca对其存在干扰（金隆铜业有限公司）。不采纳，Fe、Ca对低含量铝的干扰在误差范围内可以接受。
4. 加标回收实验中，加入标准为固体，采用十万分之一天平称取，称样量过低；测定值超过标准曲线范围（金隆铜业有限公司）。不采纳，采用加入标准溶液方式进行加标回收实验。
5. 加标回收实验中，测定值超过曲线范围。不采纳，研究过程中可以通过增加稀释倍数和增加曲线高点进行测定。
6. 实验部分“9 试验结果处理”中减去空白*ρ0*与“8.4 测定”中8.4.3 空白校正是否存在重复减去空白值的情况（金隆铜业有限公司）。采纳，调整为曲线计算中不扣空白。
7. 增加除熔剂水分步骤。加入2g混合熔剂后，将铂金坩埚放在马弗炉门口3min左右，以除去熔剂携带的水分，然后将铂金坩埚移入马弗炉内。否则，熔剂熔融时，易喷溅（郴州市产商品质量监督检验所）。不采纳，熔剂应在干燥环境中储存，未发现此现象。
8. 熔剂用碳酸钠（工作基准）、碳酸钾（分析纯）、硼酸（分析纯）亦可行。（紫金铜业有限公司）。不采纳，同第2条。
9. 用ICP检测时出现堵塞雾化器的现象，是由于碱熔的方法使溶液中钠离子的含量较高，建议增加稀释倍数或检测样品的间隔清洗时间要延长，否则连续进样很容易造成盐分析出沉积而影响雾化效率（紫金铜业有限公司）。不采纳，稀释倍数过大，不利于低含量样品的测定。

**二、标准编制原则**

本标准是根据GB/T1.1-2009《标准化工作导则 第1部分：标准的结构和编写规则》和GB/T20001.4-2001《标准编写规则 第4部分：化学分析方法》的要求进行编写的。编制本标准的目的是以能满足铜精矿中增加的铬、氧化铝含量的准确快速测定要求为基础。编制本标准的原则是准确、具有一定的先进性和操作简单性。根据国情制订技术规范并力求与国外先进技术接轨。

**三、标准主要内容的确定依据**

3.1含量范围确定及使用检测手段确定

根据江西铜业股份有限公司、铜陵有色金属集团控股有限公司、大冶有色设计研究院有限公司等单位提供的铜精矿试样以及在实际生产中遇到的样品，确定铜精矿中增加的铬、氧化铝量的测定范围。为了达到多元素同时检测的目的，以及出于相关元素检测范围的考虑，选择市场上应用广泛的电感耦合等离子体原子发射光谱仪。

3.2干扰及消除

主要考察了铜精矿中金属元素铜和铁，以及共存的砷、锑、铋、铅、锌、镍、镉、钴、钙、镁等元素对待测元素的干扰。根据铜精矿中各元素的含量范围上限，按本方法的稀释倍数（称样量为0.2000g，定容于100mL容量瓶，稀释10倍测定）计算出测定溶液中各元素的干扰量，实验报告说明。干扰元素实验结果说明溶液中各杂质元素对待测元素测定不干扰。

3.3重复性及再现性

铜精矿中铬、氧化铝的原始数据及原始数据统计检验过程见《实验数据及处理》第一部分至第三部分。剔除离群值后，重复性、再现性计算结果见表2。

表2 重复性和再现性

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *wCr/%* | 0.047 | 0.17 | 0.78 | 1.12 | 1.99 | 4.00 |
| *r*/% | 0.007 | 0.02 | 0.04 | 0.05 | 0.11 | 0.15 |
| *w*Al2O3/% | 0.70 | 1.63 | 4.10 | 5.96 | 8.03 |  |
| *r*/% | 0.06 | 0.08 | 0.17 | 0.20 | 0.27 |  |
| *wCr/%* | 0.047 | 0.17 | 0.78 | 1.12 | 1.99 | 4.00 |
| *R*/% | 0.012 | 0.03 | 0.06 | 0.08 | 0.14 | 0.21 |
| *w*Al2O3/% | 0.70 | 1.63 | 4.10 | 5.96 | 8.03 |  |
| *R*/% | 0.07 | 0.12 | 0.21 | 0.36 | 0.41 |  |

3.4样品加标回收率

选取6、1、2、5号样品按分析步骤进行标准加入回收试验，其结果见表3。从表3中看样品Al2O3的加标回收率在96.0%~102.0%之间，Cr的加标回收率在98.5%~104.3%之间，回收率较好，可作为行业标准方法推广使用。

表3 加标回收实验

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 元素及样品 | | 称样量/g | 含量/% | 含量/μg | 加入量/μg | 测得量/μg | 回收率/% |
| Al2O3 | 6 | 0.2000 | 0.72 | 1440 | 1000 | 2460 | 102.0 |
| 1 | 0.2000 | 4.13 | 8260 | 8000 | 16212 | 99.40 |
| 2 | 0.2000 | 8.09 | 16180 | 15000 | 30575 | 96.0 |
| Cr | 6 | 0.2000 | 0.045 | 90 | 100 | 194 | 104.0 |
| 2 | 0.2000 | 0.79 | 1580 | 1500 | 3144 | 104.3 |
| 5 | 0.2000 | 4.03 | 8060 | 8000 | 15942 | 98.5 |

**四、标准水平分析**

经过资料搜索，均无与铜精矿中铬、氧化铝测定相关的分析标准。本标准是首次修订，填补了国际、国内铜精矿中铬、氧化铝含量测定标准的空白。验证单位一致认为：《铜精矿化学分析方法》系列标准的编写符合GB/T 1.1-2009《标准化工作导则》的编制要求。该标准技术先进、可操作性强，结构合理、文字简练、条理清晰，达到了国内先进水平。

**五、与现行法律、法规、强制性国家标准及相关标准协调配套的情况**

本标准完全满足现行法律、法规等的要求，标准格式规范。

**六、标准中涉及到的专利**

无

**七、重大分歧意见的处理经过和依据**

无

**八、标准作为强制性或推荐性国家（或行业）标准的建议**

建议该标准作为推荐性国家标准。

**九、贯彻标准的要求和措施建议**

无

**十、废止现行有关标准的建议**

本标准为首次修订，替代现行有关标准GB/T 3884.18-2014《铜精矿化学分析方法 第18部分：砷、锑、铋、铅、锌、镍、镉、钴、氧化镁、氧化钙含量的测定 电感耦合等离子体原子发射光谱法》。

**十一、其他应予说明的事项**

本标准首次规定了铜精矿中铬、氧化铝含量的测定方法。本标准在修订过程中，调研了国内多家选矿、冶炼企业，标准技术先进，具有充分的可操作性、适用性，完全能够满足国内外用户、市场的需求。本标准为铜精矿中铬、氧化铝含量的测定提供依据，有利于企业提高对铜精矿的综合利用，实现资源循环利用及有价金属材料生产。

附试验数据处理：

铜精矿化学分析方法

第18部分：砷、锑、铋、铅、锌、镍、镉、钴、铬、氧化铝、氧化镁、氧化钙含量的测定 电感耦合等离子体原子发射光谱法

由北矿检测技术有限公司江西铜业股份有限公司、铜陵有色金属集团控股有限公司、大冶有色设计研究院有限公司、中国有色桂林矿产地质研究院有限公司、安徽国家铜铅锌及制品质量监督检验中心、金隆铜业有限公司、金川集团股份有限公司、郴州市产商品质量监督检验所、紫金铜业有限公司、昆明冶金研究院有限公司、浙江华友钴业股份有限公司、山西北方铜业有限公司、福建紫金矿冶测试技术有限公司、中国检验认证集团广西有限公司、国合通用（青岛）测试评价有限公司、山东恒邦冶炼股份有限公司、中国检验认证集团广东有限公司黄埔分公司、湖南有色金属研究院有限责任公司、黑龙江紫金铜业有限公司按照标准草案要求对每个样品各进行7次独立测定。按照GB/T 6379.2-2004确定标准测量方法的重复性和再现性的基本方法的规定，对收到的数据进行了统计分析。

**1．实验室编号**

|  |  |
| --- | --- |
| 实验室编号 | 验证单位名称 |
| 1 | 铜陵有色金属集团控股有限公司 |
| 2 | 大冶有色设计研究院有限公司 |
| 3 | 中国有色桂林矿产地质研究院有限公司 |
| 4 | 安徽国家铜铅锌及制品质量监督检验中心 |
| 5 | 金隆铜业有限公司 |
| 6 | 金川集团股份有限公司 |
| 7 | 郴州市产商品质量监督检验所 |
| 8 | 紫金铜业有限公司 |
| 9 | 昆明冶金研究院有限公司 |
| 10 | 浙江华友钴业股份有限公司 |
| 11 | 山西北方铜业有限公司 |
| 12 | 福建紫金矿冶测试技术有限公司 |
| 13 | 中国检验认证集团广西有限公司 |
| 14 | 国合通用（青岛）测试评价有限公司 |
| 15 | 山东恒邦冶炼股份有限公司 |
| 16 | 中国检验认证集团广东有限公司黄埔分公司 |
| 17 | 湖南有色金属研究院有限责任公司 |
| 18 | 黑龙江紫金铜业有限公司 |
| 19 | 北矿检测技术有限公司 |

**2、各实验室内数据的格拉布斯检验。**

汇总了各实验室试验的原始数据，在柯克伦检验之前，为防止一个实验室内较高的变异来自某个测试结果，对各实验室内每个水平的的数据进行格拉布斯检验（n=7，G(0.95,7)=1.938，G(0.99,7)=2.097）。

表2-1 各实验室铬数据的格拉布斯检验

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 实验室1 | Cr | | | | | | | | | | | | | | | | | | | | | 实验室2 | Cr | | | | | | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | | 1 | | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | 样品  编号 | 6 | | | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 | | |
| 样品测定结果，% | 0.049 | | 0.178 | | | | | 0.776 | | | | 1.122 | | | | 2.013 | | | | 4.042 | | 样品测定结果，% | 0.046 | | | 0.158 | | | | | 0.799 | | | | | 1.136 | | | | | 2.020 | | | | | 4.080 | | |
| 0.048 | | 0.174 | | | | | 0.790 | | | | 1.106 | | | | 1.997 | | | | 4.016 | | 0.043 | | | 0.172 | | | | | 0.780 | | | | | 1.145 | | | | | 1.985 | | | | | 4.121 | | |
| 0.044 | | 0.170 | | | | | 0.803 | | | | 1.089 | | | | 2.005 | | | | 4.020 | | 0.047 | | | 0.178 | | | | | 0.777 | | | | | 1.148 | | | | | 1.992 | | | | | 4.005 | | |
| 0.041 | | 0.153 | | | | | 0.791 | | | | 1.110 | | | | 1.974 | | | | 4.207 | | 0.045 | | | 0.160 | | | | | 0.783 | | | | | 1.129 | | | | | 2.007 | | | | | 3.988 | | |
| 0.045 | | 0.172 | | | | | 0.806 | | | | 1.115 | | | | 1.946 | | | | 4.162 | | 0.043 | | | 0.168 | | | | | 0.789 | | | | | 1.133 | | | | | 2.004 | | | | | 3.997 | | |
| 0.046 | | 0.170 | | | | | 0.825 | | | | 1.140 | | | | 1.963 | | | | 3.958 | | 0.048 | | | 0.176 | | | | | 0.785 | | | | | 1.148 | | | | | 1.995 | | | | | 4.009 | | |
| 0.047 | | 0.162 | | | | | 0.776 | | | | 1.180 | | | | 2.027 | | | | 3.959 | | 0.042 | | | 0.165 | | | | | 0.790 | | | | | 1.141 | | | | | 1.992 | | | | | 4.011 | | |
| 平均值/% | 0.046 | | 0.168 | | | | | 0.795 | | | | 1.123 | | | | 1.989 | | | | 4.052 | | 平均值/% | 0.045 | | | 0.168 | | | | | 0.786 | | | | | 1.14 | | | | | 1.999 | | | | | 4.03 | | |
| s/% | 0.0026 | | 0.0083 | | | | | 0.0176 | | | | 0.0294 | | | | 0.029 | | | | 0.0967 | | s/% | 0.0021 | | | 0.0071 | | | | | 0.0068 | | | | | 0.007 | | | | | 0.011 | | | | | 0.0464 | | |
| RSD/% | 5.63 | | 4.93 | | | | | 2.21 | | | | 2.61 | | | | 1.46 | | | | 2.39 | | RSD/% | 4.68 | | | 4.22 | | | | | 0.86 | | | | | 0.61 | | | | | 0.55 | | | | | 1.15 | | |
| 最小值 | 0.041 | | 0.153 | | | | | 0.776 | | | | 1.089 | | | | 1.946 | | | | 3.958 | | 最小值 | 0.042 | | | 0.158 | | | | | 0.777 | | | | | 1.129 | | | | | 1.985 | | | | | 3.988 | | |
| 最大值 | 0.049 | | 0.178 | | | | | 0.825 | | | | 1.180 | | | | 2.027 | | | | 4.207 | | 最大值 | 0.048 | | | 0.178 | | | | | 0.799 | | | | | 1.148 | | | | | 2.020 | | | | | 4.121 | | |
| Gmin | 1.923 | | 1.807 | | | | | 1.080 | | | | 1.156 | | | | 1.483 | | | | 0.972 | | Gmin | 1.429 | | | 1.408 | | | | | 1.324 | | | | | 1.571 | | | | | 1.273 | | | | | 0.905 | | |
| Gmax | 1.154 | | 1.205 | | | | | 1.705 | | | | 1.939 | | | | 1.310 | | | | 1.603 | | Gmax | 1.429 | | | 1.408 | | | | | 1.912 | | | | | 1.143 | | | | | 1.909 | | | | | 1.961 | | |
| 实验室3 | Cr | | | | | | | | | | | | | | | | | | | | | 实验室4 | Cr | | | | | | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | | 1 | | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | 样品  编号 | 6 | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 | | | | |
| 样品测定结果，% | 0.044 | | 0.172 | | | | | 0.785 | | | | 1.127 | | | | 2.002 | | | | 4.069 | | 样品测定结果，% | 0.050 | 0.159 | | | | | 0.783 | | | | | 1.084 | | | | | 1.996 | | | | | 4.022 | | | | |
| 0.042 | | 0.168 | | | | | 0.772 | | | | 1.117 | | | | 2.028 | | | | 4.066 | | 0.049 | 0.178 | | | | | 0.818 | | | | | 1.109 | | | | | 2.017 | | | | | 4.035 | | | | |
| 0.042 | | 0.161 | | | | | 0.778 | | | | 1.136 | | | | 1.990 | | | | 4.118 | | 0.052 | 0.167 | | | | | 0.779 | | | | | 1.126 | | | | | 1.952 | | | | | 3.992 | | | | |
| 0.045 | | 0.161 | | | | | 0.745 | | | | 1.121 | | | | 1.984 | | | | 3.925 | | 0.053 | 0.160 | | | | | 0.790 | | | | | 1.113 | | | | | 1.965 | | | | | 4.027 | | | | |
| 0.041 | | 0.167 | | | | | 0.793 | | | | 1.132 | | | | 1.982 | | | | 3.938 | | 0.051 | 0.166 | | | | | 0.761 | | | | | 1.130 | | | | | 2.025 | | | | | 4.019 | | | | |
| 0.039 | | 0.169 | | | | | 0.756 | | | | 1.134 | | | | 1.986 | | | | 4.056 | | 0.045 | 0.172 | | | | | 0.798 | | | | | 1.091 | | | | | 2.020 | | | | | 3.984 | | | | |
| 0.044 | | 0.162 | | | | | 0.762 | | | | 1.121 | | | | 2.036 | | | | 4.061 | | 0.043 | 0.181 | | | | | 0.753 | | | | | 1.148 | | | | | 1.978 | | | | | 4.020 | | | | |
| 平均值/% | 0.042 | | 0.166 | | | | | 0.77 | | | | 1.127 | | | | 2.001 | | | | 4.033 | | 平均值/% | 0.049 | 0.169 | | | | | 0.783 | | | | | 1.114 | | | | | 1.993 | | | | | 4.014 | | | | |
| s/% | 0.002 | | 0.004 | | | | | 0.017 | | | | 0.007 | | | | 0.022 | | | | 0.073 | | s/% | 0.004 | 0.008 | | | | | 0.022 | | | | | 0.022 | | | | | 0.029 | | | | | 0.019 | | | | |
| RSD/% | 4.642 | | 2.586 | | | | | 2.193 | | | | 0.661 | | | | 1.11 | | | | 1.802 | | RSD/% | 7.54 | 4.97 | | | | | 2.81 | | | | | 2.01 | | | | | 1.45 | | | | | 0.47 | | | | |
| 最小值 | 0.039 | | 0.161 | | | | | 0.745 | | | | 1.117 | | | | 1.982 | | | | 3.925 | | 最小值 | 0.043 | 0.159 | | | | | 0.753 | | | | | 1.084 | | | | | 1.952 | | | | | 3.984 | | | | |
| 最大值 | 0.045 | | 0.172 | | | | | 0.793 | | | | 1.136 | | | | 2.036 | | | | 4.118 | | 最大值 | 0.053 | 0.181 | | | | | 0.818 | | | | | 1.148 | | | | | 2.025 | | | | | 4.035 | | | | |
| Gmin | 1.500 | | 1.250 | | | | | 1.471 | | | | 1.429 | | | | 0.864 | | | | 1.479 | | Gmin | 1.622 | 1.190 | | | | | 1.364 | | | | | 1.339 | | | | | 1.419 | | | | | 1.596 | | | | |
| Gmax | 1.500 | | 1.500 | | | | | 1.353 | | | | 1.286 | | | | 1.591 | | | | 1.164 | | Gmax | 1.081 | 1.429 | | | | | 1.591 | | | | | 1.518 | | | | | 1.107 | | | | | 1.117 | | | | |
| 实验室5 | Cr | | | | | | | | | | | | | | | | | | | | | 实验室6 | Cr | | | | | | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | | | | 1 | | | | 2 | | | | 3 | | | | 4 | | | | 5 | 样品  编号 | 6 | | | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 | | |
| 样品测定结果，% | 0.048 | | | | 0.154 | | | | 0.779 | | | | 1.055 | | | | 1.990 | | | | 4.029 | 样品测定结果，% | 0.044 | | | 0.169 | | | | | 0.795 | | | | | 1.156 | | | | | 1.994 | | | | | 4.033 | | |
| 0.043 | | | | 0.171 | | | | 0.808 | | | | 1.077 | | | | 2.037 | | | | 4.016 | 0.047 | | | 0.166 | | | | | 0.796 | | | | | 1.140 | | | | | 2.012 | | | | | 4.034 | | |
| 0.061 | | | | 0.141 | | | | 0.762 | | | | 1.099 | | | | 1.952 | | | | 3.982 | 0.044 | | | 0.167 | | | | | 0.808 | | | | | 1.144 | | | | | 2.003 | | | | | 4.075 | | |
| 0.058 | | | | 0.151 | | | | 0.790 | | | | 1.092 | | | | 1.956 | | | | 3.968 | 0.043 | | | 0.172 | | | | | 0.802 | | | | | 1.138 | | | | | 2.015 | | | | | 4.044 | | |
| 0.054 | | | | 0.157 | | | | 0.766 | | | | 1.097 | | | | 2.038 | | | | 3.983 | 0.043 | | | 0.182 | | | | | 0.777 | | | | | 1.128 | | | | | 2.023 | | | | | 3.992 | | |
| 0.047 | | | | 0.159 | | | | 0.789 | | | | 1.082 | | | | 1.991 | | | | 3.995 | 0.042 | | | 0.178 | | | | | 0.777 | | | | | 1.150 | | | | | 1.990 | | | | | 3.986 | | |
| 0.041 | | | | 0.181 | | | | 0.788 | | | | 1.086 | | | | 1.966 | | | | 4.019 | 0.042 | | | 0.181 | | | | | 0.798 | | | | | 1.132 | | | | | 2.022 | | | | | 3.976 | | |
| 平均值/% | 0.050 | | | | 0.159 | | | | 0.783 | | | | 1.084 | | | | 1.990 | | | | 3.999 | 平均值/% | 0.044 | | | 0.174 | | | | | 0.793 | | | | | 1.141 | | | | | 2.008 | | | | | 4.020 | | |
| s/% | 0.008 | | | | 0.013 | | | | 0.016 | | | | 0.015 | | | | 0.036 | | | | 0.023 | s/% | 0.002 | | | 0.006 | | | | | 0.011 | | | | | 0.009 | | | | | 0.012 | | | | | 0.034 | | |
| RSD/% | 15.050 | | | | 8.290 | | | | 2.010 | | | | 1.390 | | | | 1.800 | | | | 0.570 | RSD/% | 3.650 | | | 3.580 | | | | | 1.390 | | | | | 0.790 | | | | | 0.600 | | | | | 0.830 | | |
| 最小值 | 0.041 | | | | 0.141 | | | | 0.762 | | | | 1.055 | | | | 1.952 | | | | 3.968 | 最小值 | 0.042 | | | 0.166 | | | | | 0.777 | | | | | 1.128 | | | | | 1.990 | | | | | 3.976 | | |
| 最大值 | 0.061 | | | | 0.181 | | | | 0.808 | | | | 1.099 | | | | 2.038 | | | | 4.029 | 最大值 | 0.047 | | | 0.182 | | | | | 0.808 | | | | | 1.156 | | | | | 2.023 | | | | | 4.075 | | |
| Gmin | 1.184 | | | | 1.364 | | | | 1.338 | | | | 1.933 | | | | 1.061 | | | | 1.360 | Gmin | 1.250 | | | 1.290 | | | | | 1.441 | | | | | 1.429 | | | | | 1.488 | | | | | 1.313 | | |
| Gmax | 1.447 | | | | 1.667 | | | | 1.592 | | | | 1.000 | | | | 1.341 | | | | 1.316 | Gmax | 1.875 | | | 1.290 | | | | | 1.351 | | | | | 1.648 | | | | | 1.240 | | | | | 1.642 | | |
| 实验室7 | Cr | | | | | | | | | | | | | | | | | | | | | 实验室8 | Cr | | | | | | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | | 1 | | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | 样品  编号 | 6 | | | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 | | |
| 样品测定结果，% | 0.047 | | 0.186 | | | | | 0.792 | | | | 1.128 | | | | 1.989 | | | | 3.975 | | 样品测定结果，% | 0.042 | | | 0.170 | | | | | 0.788 | | | | | 1.163 | | | | | 1.993 | | | | | 4.055 | | |
| 0.046 | | 0.186 | | | | | 0.792 | | | | 1.149 | | | | 1.926 | | | | 3.982 | | 0.047 | | | 0.173 | | | | | 0.782 | | | | | 1.143 | | | | | 2.003 | | | | | 3.952 | | |
| 0.048 | | 0.182 | | | | | 0.801 | | | | 1.136 | | | | 1.966 | | | | 3.976 | | 0.043 | | | 0.161 | | | | | 0.768 | | | | | 1.109 | | | | | 1.952 | | | | | 3.954 | | |
| 0.045 | | 0.189 | | | | | 0.806 | | | | 1.132 | | | | 1.982 | | | | 3.996 | | 0.046 | | | 0.167 | | | | | 0.771 | | | | | 1.114 | | | | | 1.994 | | | | | 4.091 | | |
| 0.044 | | 0.187 | | | | | 0.789 | | | | 1.124 | | | | 1.947 | | | | 3.974 | | 0.044 | | | 0.177 | | | | | 0.818 | | | | | 1.127 | | | | | 1.980 | | | | | 4.063 | | |
| 0.048 | | 0.182 | | | | | 0.792 | | | | 1.145 | | | | 2.001 | | | | 4.016 | | 0.045 | | | 0.172 | | | | | 0.796 | | | | | 1.155 | | | | | 1.996 | | | | | 4.007 | | |
| 0.047 | | 0.181 | | | | | 0.804 | | | | 1.126 | | | | 1.999 | | | | 4.027 | | 0.047 | | | 0.169 | | | | | 0.785 | | | | | 1.157 | | | | | 2.008 | | | | | 4.080 | | |
| 平均值（%） | 0.046 | | 0.185 | | | | | 0.797 | | | | 1.134 | | | | 1.973 | | | | 3.992 | | 平均值（%） | 0.045 | | | 0.17 | | | | | 0.787 | | | | | 1.138 | | | | | 1.989 | | | | | 4.029 | | |
| s/% | 0.0015 | | 0.003 | | | | | 0.0069 | | | | 0.0096 | | | | 0.0281 | | | | 0.0215 | | s/% | 0.002 | | | 0.005 | | | | | 0.0168 | | | | | 0.0217 | | | | | 0.0187 | | | | | 0.0582 | | |
| RSD(%) | 3.26 | | 1.65 | | | | | 0.86 | | | | 0.85 | | | | 1.42 | | | | 0.54 | | RSD(%) | 4.35 | | | 2.97 | | | | | 2.13 | | | | | 1.91 | | | | | 0.94 | | | | | 1.44 | | |
| 最小值 | 0.044 | | 0.181 | | | | | 0.789 | | | | 1.124 | | | | 1.926 | | | | 3.974 | | 最小值 | 0.042 | | | 0.161 | | | | | 0.768 | | | | | 1.109 | | | | | 1.952 | | | | | 3.952 | | |
| 最大值 | 0.048 | | 0.189 | | | | | 0.806 | | | | 1.149 | | | | 2.001 | | | | 4.027 | | 最大值 | 0.047 | | | 0.177 | | | | | 0.818 | | | | | 1.163 | | | | | 2.008 | | | | | 4.091 | | |
| Gmin | 1.333 | | 1.333 | | | | | 1.159 | | | | 1.042 | | | | 1.673 | | | | 0.837 | | Gmin | 1.500 | | | 1.800 | | | | | 1.131 | | | | | 1.336 | | | | | 1.979 | | | | | 1.323 | | |
| Gmax | 1.333 | | 1.333 | | | | | 1.304 | | | | 1.563 | | | | 0.996 | | | | 1.628 | | Gmax | 1.000 | | | 1.400 | | | | | 1.845 | | | | | 1.152 | | | | | 1.016 | | | | | 1.065 | | |
| 实验室9 | Cr | | | | | | | | | | | | | | | | | | | | | 实验室10 | Cr | | | | | | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | | 1 | | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | 样品  编号 | 6 | | | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 | | |
| 样品测定结果，% | 0.044 | | 0.178 | | | | | 0.786 | | | | 1.139 | | | | 2.025 | | | | 3.904 | | 样品测定结果，% | 0.053 | | | 0.182 | | | | | 0.781 | | | | | 1.171 | | | | | 2.014 | | | | | 4.203 | | |
| 0.046 | | 0.187 | | | | | 0.780 | | | | 1.112 | | | | 2.020 | | | | 3.967 | | 0.049 | | | 0.179 | | | | | 0.832 | | | | | 1.156 | | | | | 2.035 | | | | | 3.957 | | |
| 0.047 | | 0.171 | | | | | 0.787 | | | | 1.147 | | | | 2.012 | | | | 4.018 | | 0.043 | | | 0.156 | | | | | 0.775 | | | | | 1.135 | | | | | 1.982 | | | | | 3.962 | | |
| 0.048 | | 0.172 | | | | | 0.782 | | | | 1.121 | | | | 2.012 | | | | 4.017 | | 0.052 | | | 0.161 | | | | | 0.814 | | | | | 1.108 | | | | | 1.958 | | | | | 4.131 | | |
| 0.048 | | 0.169 | | | | | 0.792 | | | | 1.116 | | | | 1.995 | | | | 3.995 | | 0.045 | | | 0.181 | | | | | 0.771 | | | | | 1.134 | | | | | 2.227 | | | | | 4.187 | | |
| 0.045 | | 0.167 | | | | | 0.774 | | | | 1.106 | | | | 1.979 | | | | 3.992 | | 0.038 | | | 0.159 | | | | | 0.792 | | | | | 1.127 | | | | | 1.973 | | | | | 3.976 | | |
| 0.046 | | 0.168 | | | | | 0.785 | | | | 1.076 | | | | 1.972 | | | | 4.105 | | 0.051 | | | 0.167 | | | | | 0.805 | | | | | 1.116 | | | | | 2.164 | | | | | 3.991 | | |
| 平均值（%） | 0.046 | | 0.173 | | | | | 0.784 | | | | 1.117 | | | | 2.002 | | | | 4.000 | | 均值/% | 0.047 | | | 0.169 | | | | | 0.796 | | | | | 1.135 | | | | | 2.05 | | | | | 4.058 | | |
| s/% | 0.0015 | | 0.0071 | | | | | 0.0057 | | | | 0.0232 | | | | 0.0205 | | | | 0.0606 | | s/% | 0.005499 | | | 0.011176 | | | | | 0.022388 | | | | | 0.021952 | | | | | 0.103973 | | | | | 0.110774 | | |
| RSD(%) | 3.26 | | 4.1 | | | | | 0.73 | | | | 2.08 | | | | 1.02 | | | | 1.52 | | RSD/% | 11.7 | | | 6.61 | | | | | 2.82 | | | | | 1.94 | | | | | 5.08 | | | | | 2.72 | | |
| 最小值 | 0.044 | | 0.167 | | | | | 0.774 | | | | 1.076 | | | | 1.972 | | | | 3.904 | | 最小值 | 0.038 | | | 0.156 | | | | | 0.771 | | | | | 1.108 | | | | | 1.958 | | | | | 3.957 | | |
| 最大值 | 0.048 | | 0.187 | | | | | 0.792 | | | | 1.147 | | | | 2.025 | | | | 4.105 | | 最大值 | 0.053 | | | 0.182 | | | | | 0.832 | | | | | 1.171 | | | | | 2.227 | | | | | 4.203 | | |
| Gmin | 1.333 | | 0.845 | | | | | 1.754 | | | | 1.767 | | | | 1.463 | | | | 1.584 | | Gmin | 1.637 | | | 1.163 | | | | | 1.117 | | | | | 1.230 | | | | | 0.885 | | | | | 0.912 | | |
| Gmax | 1.333 | | 1.972 | | | | | 1.404 | | | | 1.293 | | | | 1.122 | | | | 1.733 | | Gmax | 1.091 | | | 1.163 | | | | | 1.608 | | | | | 1.640 | | | | | 1.702 | | | | | 1.309 | | |
| 实验室11 | Cr | | | | | | | | | | | | | | | | | | | | | 实验室12 | Cr | | | | | | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | | 1 | | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | 样品  编号 | 6 | | | | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 | |
| 样品测定结果，% | 0.043 | | 0.184 | | | | | 0.816 | | | | 1.201 | | | | 1.950 | | | | 3.908 | | 样品测定结果，% | 0.043 | | | | 0.16 | | | | | 0.746 | | | | | 1.096 | | | | | 2.014 | | | | | 4.045 | |
| 0.043 | | 0.182 | | | | | 0.794 | | | | 1.182 | | | | 2.018 | | | | 4.146 | | 0.043 | | | | 0.162 | | | | | 0.751 | | | | | 1.061 | | | | | 2.065 | | | | | 4.095 | |
| 0.047 | | 0.188 | | | | | 0.821 | | | | 1.221 | | | | 2.038 | | | | 4.153 | | 0.036 | | | | 0.154 | | | | | 0.737 | | | | | 1.074 | | | | | 2.023 | | | | | 3.991 | |
| 0.048 | | 0.186 | | | | | 0.770 | | | | 1.143 | | | | 1.948 | | | | 3.894 | | 0.041 | | | | 0.163 | | | | | 0.771 | | | | | 1.106 | | | | | 2.039 | | | | | 4.127 | |
| 0.041 | | 0.166 | | | | | 0.803 | | | | 1.178 | | | | 2.033 | | | | 4.157 | | 0.041 | | | | 0.163 | | | | | 0.733 | | | | | 1.046 | | | | | 1.983 | | | | | 4.115 | |
| 0.044 | | 0.167 | | | | | 0.801 | | | | 1.174 | | | | 2.042 | | | | 4.019 | | 0.043 | | | | 0.162 | | | | | 0.822 | | | | | 1.061 | | | | | 2.052 | | | | | 4.083 | |
| 0.048 | | 0.165 | | | | | 0.794 | | | | 1.192 | | | | 2.096 | | | | 4.276 | | 0.045 | | | | 0.167 | | | | | 0.724 | | | | | 1.11 | | | | | 2.047 | | | | | 4.106 | |
| 均值/% | 0.045 | | 0.177 | | | | | 0.8 | | | | 1.184 | | | | 2.018 | | | | 4.079 | | 均值/% | 0.042 | | | | 0.162 | | | | | 0.755 | | | | | 1.079 | | | | | 2.032 | | | | | 4.08 | |
| s/% | 0.0028 | | 0.0103 | | | | | 0.0167 | | | | 0.0243 | | | | 0.0529 | | | | 0.1426 | | s/% | 0.0029 | | | | 0.0040 | | | | | 0.033 | | | | | 0.025 | | | | | 0.028 | | | | | 0.047 | |
| RSD/% | 6.23 | | 5.84 | | | | | 2.09 | | | | 2.05 | | | | 2.62 | | | | 3.49 | | RSD/% | 6.881 | | | | 2.446 | | | | | 4.397 | | | | | 2.314 | | | | | 1.358 | | | | | 1.162 | |
| 最小值 | 0.041 | | 0.165 | | | | | 0.770 | | | | 1.143 | | | | 1.948 | | | | 3.894 | | 最小值 | 0.036 | | | | 0.154 | | | | | 0.724 | | | | | 1.046 | | | | | 1.983 | | | | | 3.991 | |
| 最大值 | 0.048 | | 0.188 | | | | | 0.821 | | | | 1.221 | | | | 2.096 | | | | 4.276 | | 最大值 | 0.045 | | | | 0.167 | | | | | 0.822 | | | | | 1.110 | | | | | 2.065 | | | | | 4.127 | |
| Gmin | 1.429 | | 1.165 | | | | | 1.796 | | | | 1.687 | | | | 1.323 | | | | 1.297 | | Gmin | 2.090 | | | | 2.024 | | | | | 0.939 | | | | | 1.320 | | | | | 1.750 | | | | | 1.894 | |
| Gmax | 1.071 | | 1.068 | | | | | 1.257 | | | | 1.523 | | | | 1.474 | | | | 1.381 | | Gmax | 1.045 | | | | 1.265 | | | | | 2.030 | | | | | 1.240 | | | | | 1.179 | | | | | 1.000 | |
| 实验室13 | Cr | | | | | | | | | | | | | | | | | | | | | 实验室14 | Cr | | | | | | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | 1 | | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | | 样品  编号 | 6 | | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 | | | |
| 样品测定结果，% | 0.055 | 0.185 | | | | | 0.752 | | | | ~~1.168~~ | | | | 1.858 | | | | 3.804 | | | 样品测定结果，% | 0.044 | | 0.172 | | | | | 0.752 | | | | | 1.093 | | | | | 1.986 | | | | | 4.058 | | | |
| 0.048 | 0.170 | | | | | 0.770 | | | | 1.125 | | | | 1.883 | | | | 3.889 | | | 0.044 | | 0.168 | | | | | 0.747 | | | | | 1.103 | | | | | 1.965 | | | | | 4.103 | | | |
| 0.050 | 0.188 | | | | | 0.779 | | | | 1.118 | | | | 1.965 | | | | 3.854 | | | 0.048 | | 0.175 | | | | | 0.758 | | | | | 1.111 | | | | | 1.978 | | | | | 3.982 | | | |
| 0.053 | 0.182 | | | | | 0.776 | | | | 1.134 | | | | 1.925 | | | | 3.910 | | | 0.046 | | 0.176 | | | | | 0.783 | | | | | 1.107 | | | | | 1.981 | | | | | 3.955 | | | |
| 0.045 | 0.181 | | | | | 0.760 | | | | 1.122 | | | | 1.892 | | | | 3.821 | | | 0.041 | | 0.162 | | | | | 0.754 | | | | | 1.089 | | | | | 1.959 | | | | | 3.998 | | | |
| 0.052 | 0.172 | | | | | 0.774 | | | | 1.135 | | | | 1.871 | | | | 3.902 | | | 0.043 | | 0.172 | | | | | 0.789 | | | | | 1.070 | | | | | 2.035 | | | | | 3.974 | | | |
| 0.050 | 0.175 | | | | | 0.781 | | | | 1.123 | | | | 1.881 | | | | 3.897 | | | 0.048 | | 0.159 | | | | | 0.754 | | | | | 1.089 | | | | | 2.022 | | | | | 3.932 | | | |
| 均值/% | 0.050 | 0.179 | | | | | 0.770 | | | | 1.132 | | | | 1.896 | | | | 3.868 | | | 均值/% | 0.045 | | 0.169 | | | | | 0.762 | | | | | 1.094 | | | | | 1.989 | | | | | 4.000 | | | |
| s/% | 0.0033 | 0.0068 | | | | | 0.0106 | | | | 0.0170 | | | | 0.0367 | | | | 0.0422 | | | s/% | 0.0024 | | 0.0064 | | | | | 0.0165 | | | | | 0.0139 | | | | | 0.0284 | | | | | 0.0601 | | | |
| RSD/% | 6.881 | 2.446 | | | | | 4.397 | | | | 2.314 | | | | 1.358 | | | | 1.162 | | | RSD/% | 5.43 | | 3.8 | | | | | 2.16 | | | | | 1.27 | | | | | 1.43 | | | | | 1.5 | | | |
| 最小值 | 0.045 | 0.170 | | | | | 0.752 | | | | 1.118 | | | | 1.858 | | | | 3.804 | | | 最小值 | 0.041 | | 0.159 | | | | | 0.747 | | | | | 1.070 | | | | | 1.959 | | | | | 3.932 | | | |
| 最大值 | 0.055 | 0.188 | | | | | 0.781 | | | | 1.168 | | | | 1.965 | | | | 3.910 | | | 最大值 | 0.048 | | 0.176 | | | | | 0.789 | | | | | 1.111 | | | | | 2.035 | | | | | 4.103 | | | |
| Gmin | 1.511 | 1.327 | | | | | 1.694 | | | | 0.832 | | | | 1.036 | | | | 1.515 | | | Gmin | 1.667 | | 1.563 | | | | | 0.909 | | | | | 1.727 | | | | | 1.056 | | | | | 1.131 | | | |
| Gmax | 1.511 | 1.327 | | | | | 1.035 | | | | 2.109 | | | | 1.880 | | | | 0.994 | | | Gmax | 1.250 | | 1.094 | | | | | 1.636 | | | | | 1.223 | | | | | 1.620 | | | | | 1.714 | | | |
| 实验室15 | Cr | | | | | | | | | | | | | | | | | | | | | 实验室16 | Cr | | | | | | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | | 1 | | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | 样品  编号 | 6 | | | | | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 |
| 样品测定结果，% | 0.044 | | 0.163 | | | | | 0.765 | | | | 1.035 | | | | 1.852 | | | | 3.878 | | 样品测定结果，% | 0.056 | | | | | 0.180 | | | | | 0.803 | | | | | 1.109 | | | | | 1.920 | | | | | 3.960 |
| 0.046 | | 0.154 | | | | | 0.787 | | | | 1.056 | | | | 1.882 | | | | 3.824 | | 0.058 | | | | | 0.178 | | | | | 0.800 | | | | | 1.103 | | | | | 1.929 | | | | | 3.956 |
| 0.051 | | 0.154 | | | | | 0.775 | | | | 1.021 | | | | 1.821 | | | | 3.917 | | 0.055 | | | | | 0.194 | | | | | 0.805 | | | | | 1.097 | | | | | 1.941 | | | | | 3.935 |
| 0.045 | | 0.159 | | | | | 0.742 | | | | 1.041 | | | | 1.882 | | | | 3.885 | | 0.058 | | | | | 0.190 | | | | | 0.803 | | | | | 1.110 | | | | | 1.929 | | | | | 3.945 |
| 0.052 | | 0.171 | | | | | 0.748 | | | | 1.058 | | | | 1.864 | | | | 3.856 | | 0.054 | | | | | 0.176 | | | | | 0.806 | | | | | 1.110 | | | | | 1.952 | | | | | 3.926 |
| 0.051 | | 0.161 | | | | | 0.753 | | | | 1.029 | | | | 1.893 | | | | 3.894 | | 0.054 | | | | | 0.177 | | | | | 0.795 | | | | | 1.133 | | | | | 1.963 | | | | | 3.914 |
| 0.047 | | 0.158 | | | | | 0.762 | | | | 1.076 | | | | 1.901 | | | | 3.924 | | 0.056 | | | | | 0.184 | | | | | 0.788 | | | | | 1.114 | | | | | 1.964 | | | | | 4.006 |
| 平均值/% | 0.048 | | 0.16 | | | | | 0.762 | | | | 1.045 | | | | 1.871 | | | | 3.883 | | 平均值/% | 0.055 | | | | | 0.183 | | | | | 0.800 | | | | | 1.111 | | | | | 1.943 | | | | | 3.949 |
| s/% | 0.0033 | | 0.0059 | | | | | 0.0157 | | | | 0.0191 | | | | 0.0275 | | | | 0.0346 | | s/% | 0.0017 | | | | | 0.0069 | | | | | 0.0064 | | | | | 0.0112 | | | | | 0.0175 | | | | | 0.03 |
| RSD/% | 6.8 | | 3.68 | | | | | 2.06 | | | | 1.83 | | | | 1.47 | | | | 0.89 | | RSD/% | 1.64 | | | | | 3.8 | | | | | 0.804 | | | | | 1.01 | | | | | 0.903 | | | | | 0.759 |
| 最小值 | 0.044 | | 0.154 | | | | | 0.742 | | | | 1.021 | | | | 1.821 | | | | 3.824 | | 最小值 | 0.054 | | | | | 0.176 | | | | | 0.788 | | | | | 1.097 | | | | | 1.920 | | | | | 3.914 |
| 最大值 | 0.052 | | 0.171 | | | | | 0.787 | | | | 1.076 | | | | 1.901 | | | | 3.924 | | 最大值 | 0.058 | | | | | 0.194 | | | | | 0.806 | | | | | 1.133 | | | | | 1.964 | | | | | 4.006 |
| Gmin | 1.212 | | 1.017 | | | | | 1.274 | | | | 1.257 | | | | 1.818 | | | | 1.705 | | Gmin | 0.597 | | | | | 1.014 | | | | | 1.875 | | | | | 1.250 | | | | | 1.314 | | | | | 1.167 |
| Gmax | 1.212 | | 1.864 | | | | | 1.592 | | | | 1.623 | | | | 1.091 | | | | 1.185 | | Gmax | 1.790 | | | | | 1.594 | | | | | 0.938 | | | | | 1.964 | | | | | 1.200 | | | | | 1.900 |
| 实验室17 | Cr | | | | | | | | | | | | | | | | | | | | | 实验室18 | Cr | | | | | | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | | | 1 | | 2 | | | | 3 | | | | 4 | | | | 5 | | | | 样品  编号 | 6 | | | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 | | |
| 样品测定结果，% | 0.058 | | | 0.180 | | 0.785 | | | | 1.102 | | | | 1.953 | | | | 3.921 | | | | 样品测定结果，% | 0.044 | | | 0.161 | | | | | 0.785 | | | | | 1.121 | | | | | 2.021 | | | | | 4.109 | | |
| 0.053 | | | 0.179 | | 0.805 | | | | 1.110 | | | | 1.921 | | | | 3.952 | | | | 0.048 | | | 0.179 | | | | | 0.792 | | | | | 1.132 | | | | | 1.969 | | | | | 3.981 | | |
| 0.056 | | | 0.195 | | 0.802 | | | | 1.108 | | | | 1.940 | | | | 3.935 | | | | 0.046 | | | 0.166 | | | | | 0.775 | | | | | 1.159 | | | | | 1.984 | | | | | 4.004 | | |
| 0.055 | | | 0.186 | | 0.798 | | | | 1.095 | | | | 1.935 | | | | 3.916 | | | | 0.042 | | | 0.173 | | | | | 0.782 | | | | | 1.142 | | | | | 1.979 | | | | | 3.927 | | |
| 0.051 | | | 0.173 | | 0.808 | | | | 1.105 | | | | 1.946 | | | | 3.948 | | | | 0.046 | | | 0.170 | | | | | 0.761 | | | | | 1.138 | | | | | 2.007 | | | | | 4.062 | | |
| 0.059 | | | 0.182 | | 0.793 | | | | 1.097 | | | | 1.923 | | | | 3.962 | | | | 0.047 | | | 0.174 | | | | | 0.815 | | | | | 1.143 | | | | | 2.031 | | | | | 4.031 | | |
| 0.054 | | | 0.192 | | 0.797 | | | | 1.095 | | | | 1.927 | | | | 3.936 | | | | 0.045 | | | 0.168 | | | | | 0.809 | | | | | 1.120 | | | | | 1.956 | | | | | 4.070 | | |
| 平均值/% | 0.055 | | | 0.184 | | 0.798 | | | | 1.102 | | | | 1.935 | | | | 3.939 | | | | 平均值/% | 0.045 | | | 0.170 | | | | | 0.788 | | | | | 1.136 | | | | | 1.992 | | | | | 4.026 | | |
| s/% | 0.0028 | | | 0.0077 | | 0.0077 | | | | 0.0062 | | | | 0.0121 | | | | 0.0166 | | | | s/% | 0.002 | | | 0.006 | | | | | 0.019 | | | | | 0.014 | | | | | 0.028 | | | | | 0.061 | | |
| RSD/% | 5.068 | | | 4.183 | | 0.97 | | | | 0.564 | | | | 0.624 | | | | 0.422 | | | | RSD/% | 4.380 | | | 3.450 | | | | | 2.390 | | | | | 1.200 | | | | | 1.400 | | | | | 1.520 | | |
| 最小值 | 0.051 | | | 0.173 | | 0.785 | | | | 1.095 | | | | 1.921 | | | | 3.916 | | | | 最小值 | 0.042 | | | 0.161 | | | | | 0.761 | | | | | 1.120 | | | | | 1.956 | | | | | 3.927 | | |
| 最大值 | 0.059 | | | 0.195 | | 0.808 | | | | 1.110 | | | | 1.953 | | | | 3.962 | | | | 最大值 | 0.048 | | | 0.179 | | | | | 0.815 | | | | | 1.159 | | | | | 2.031 | | | | | 4.109 | | |
| Gmin | 1.429 | | | 1.430 | | 1.680 | | | | 1.129 | | | | 1.157 | | | | 1.386 | | | | Gmin | 1.500 | | | 1.525 | | | | | 1.436 | | | | | 1.176 | | | | | 1.295 | | | | | 1.618 | | |
| Gmax | 1.429 | | | 1.430 | | 1.292 | | | | 1.290 | | | | 1.488 | | | | 1.386 | | | | Gmax | 1.500 | | | 1.525 | | | | | 1.436 | | | | | 1.691 | | | | | 1.403 | | | | | 1.356 | | |
| 实验室19 | Cr | | | | | | | | | | | | | | | | | | | | |
| 样品  编号 | 6 | | 1 | | | | | 2 | | | | 3 | | | | 4 | | | | 5 | |
| 样品测定结果，% | 0.045 | | 0.176 | | | | | 0.773 | | | | 1.111 | | | | 1.972 | | | | 3.961 | |
| 0.041 | | 0.174 | | | | | 0.821 | | | | 1.142 | | | | 2.021 | | | | 4.005 | |
| 0.046 | | 0.162 | | | | | 0.786 | | | | 1.124 | | | | 2.008 | | | | 3.940 | |
| 0.047 | | 0.165 | | | | | 0.805 | | | | 1.103 | | | | 1.940 | | | | 4.060 | |
| 0.048 | | 0.178 | | | | | 0.765 | | | | 1.161 | | | | 1.962 | | | | 4.104 | |
| 0.042 | | 0.158 | | | | | 0.778 | | | | 1.133 | | | | 2.031 | | | | 4.082 | |
| 0.044 | | 0.174 | | | | | 0.792 | | | | 1.151 | | | | 1.983 | | | | 4.036 | |
| 平均值/% | 0.045 | | 0.170 | | | | | 0.789 | | | | 1.132 | | | | 1.988 | | | | 4.027 | |
| s/% | 0.0026 | | 0.0078 | | | | | 0.0194 | | | | 0.021 | | | | 0.0332 | | | | 0.0613 | |
| RSD/% | 5.73 | | 4.59 | | | | | 2.46 | | | | 1.86 | | | | 1.67 | | | | 1.52 | |
| 最小值 | 0.041 | | 0.158 | | | | | 0.765 | | | | 1.103 | | | | 1.940 | | | | 3.940 | |
| 最大值 | 0.048 | | 0.178 | | | | | 0.821 | | | | 1.161 | | | | 2.031 | | | | 4.104 | |
| Gmin | 1.538 | | 1.538 | | | | | 1.237 | | | | 1.381 | | | | 1.446 | | | | 1.419 | |
| Gmax | 1.154 | | 1.026 | | | | | 1.649 | | | | 1.381 | | | | 1.295 | | | | 1.256 | |

结果表明：实验室13的样品3有离群值，剔除，对剩余6个数据进行格拉布斯，无异常值。

表2-2 各实验室氧化铝数据的格拉布斯检验

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 实验室1 | Al203 | | | | | | | | | | | | | | | | | | | | | 实验室2 | | Al203 | | | | | | | | | | | | | |
| 样品  编号 | 6 | | | 5 | | | | | 1 | | | | | 3 | | | | | 2 | | | 样品  编号 | | 6 | | 5 | | | 1 | | | | 3 | | | 2 | |
| 样品测定结果，% | 0.693 | | | 1.643 | | | | | 4.123 | | | | | 6.003 | | | | | 7.918 | | | 样品测定结果，% | | 0.723 | | 1.644 | | | 4.191 | | | | 6.138 | | | 8.198 | |
| 0.702 | | | 1.588 | | | | | 4.097 | | | | | 5.951 | | | | | 8.006 | | | 0.745 | | 1.642 | | | 4.087 | | | | 6.026 | | | 8.264 | |
| 0.722 | | | 1.622 | | | | | 4.055 | | | | | 6.013 | | | | | 7.936 | | | 0.704 | | 1.620 | | | 4.157 | | | | 5.998 | | | 8.144 | |
| 0.690 | | | 1.579 | | | | | 4.060 | | | | | 6.105 | | | | | 8.074 | | | 0.726 | | 1.611 | | | 4.094 | | | | 6.059 | | | 8.011 | |
| 0.708 | | | 1.616 | | | | | 4.020 | | | | | 5.915 | | | | | 8.258 | | | 0.699 | | 1.622 | | | 4.196 | | | | 6.123 | | | 8.111 | |
| 0.726 | | | 1.577 | | | | | 4.098 | | | | | 6.240 | | | | | 8.026 | | | 0.715 | | 1.582 | | | 4.114 | | | | 6.123 | | | 8.045 | |
| 0.719 | | | 1.591 | | | | | 4.122 | | | | | 6.118 | | | | | 7.962 | | | 0.696 | | 1.598 | | | 4.021 | | | | 6.085 | | | 8.123 | |
| 平均值/% | 0.709 | | | 1.602 | | | | | 4.082 | | | | | 6.049 | | | | | 8.026 | | | 平均值/% | | 0.715 | | 1.617 | | | 4.123 | | | | 6.079 | | | 8.128 | |
| s/% | 0.0142 | | | 0.0251 | | | | | 0.0382 | | | | | 0.1121 | | | | | 0.1157 | | | s/% | | 0.0161 | | 0.0207 | | | 0.0582 | | | | 0.0495 | | | 0.0798 | |
| RSD/% | 2.01 | | | 1.57 | | | | | 0.93 | | | | | 1.85 | | | | | 1.44 | | | RSD/% | | 2.25 | | 1.28 | | | 1.41 | | | | 0.81 | | | 0.98 | |
| 最小值 | 0.69 | | | 1.577 | | | | | 4.02 | | | | | 5.915 | | | | | 7.918 | | | 最小值 | | 0.696 | | 1.582 | | | 4.021 | | | | 5.998 | | | 8.011 | |
| 最大值 | 0.726 | | | 1.643 | | | | | 4.123 | | | | | 6.24 | | | | | 8.258 | | | 最大值 | | 0.745 | | 1.644 | | | 4.196 | | | | 6.138 | | | 8.264 | |
| Gmin | 1.338 | | | 0.996 | | | | | 1.623 | | | | | 1.195 | | | | | 0.933 | | | Gmin | | 1.180 | | 1.691 | | | 1.753 | | | | 1.636 | | | 1.466 | |
| Gmax | 1.197 | | | 1.633 | | | | | 1.073 | | | | | 1.704 | | | | | 2.005 | | | Gmax | | 1.863 | | 1.304 | | | 1.254 | | | | 1.192 | | | 1.704 | |
| 实验室3 | Al203 | | | | | | | | | | | | | | | | | | | | | 实验室4 | | Al203 | | | | | | | | | | | | | |
| 样品  编号 | 6 | | | 5 | | | | | 1 | | | | | 3 | | | | | 2 | | | 样品  编号 | | 6 | | | 5 | | | 1 | | | | 3 | 2 | | |
| 样品测定结果，% | 0.728 | | | 1.623 | | | | | 4.070 | | | | | 5.983 | | | | | 8.097 | | | 样品测定结果，% | | 0.735 | | | 1.658 | | | 4.058 | | | | 5.842 | 7.925 | | |
| 0.718 | | | 1.681 | | | | | 4.236 | | | | | 5.993 | | | | | 7.993 | | | 0.768 | | | 1.637 | | | 4.026 | | | | 5.790 | 7.916 | | |
| 0.736 | | | 1.625 | | | | | 4.152 | | | | | 6.068 | | | | | 7.934 | | | 0.694 | | | 1.655 | | | 4.087 | | | | 5.781 | 7.873 | | |
| 0.684 | | | 1.660 | | | | | 4.070 | | | | | 5.953 | | | | | 8.160 | | | 0.743 | | | 1.668 | | | 4.011 | | | | 5.775 | 7.865 | | |
| 0.692 | | | 1.665 | | | | | 4.132 | | | | | 6.035 | | | | | 7.979 | | | 0.734 | | | 1.642 | | | 4.073 | | | | 5.806 | 7.909 | | |
| 0.727 | | | 1.639 | | | | | 4.041 | | | | | 6.014 | | | | | 8.132 | | | 0.709 | | | 1.639 | | | 4.091 | | | | 5.786 | 7.885 | | |
| 0.698 | | | 1.624 | | | | | 4.065 | | | | | 5.964 | | | | | 8.065 | | | 0.751 | | | 1.660 | | | 4.121 | | | | 5.839 | 7.896 | | |
| 平均值/% | 0.712 | | | 1.645 | | | | | 4.110 | | | | | 6.001 | | | | | 8.051 | | | 平均值/% | | 0.733 | | | 1.651 | | | 4.067 | | | | 5.803 | 7.896 | | |
| s/% | 0.02 | | | 0.023 | | | | | 0.068 | | | | | 0.041 | | | | | 0.085 | | | s/% | | 0.025 | | | 0.0119 | | | 0.0383 | | | | 0.0275 | 0.0224 | | |
| RSD/% | 2.852 | | | 1.413 | | | | | 1.663 | | | | | 0.676 | | | | | 1.052 | | | RSD/% | | 3.41 | | | 0.72 | | | 0.94 | | | | 0.47 | 0.28 | | |
| 最小值 | 0.684 | | | 1.623 | | | | | 4.041 | | | | | 5.953 | | | | | 7.934 | | | 最小值 | | 0.694 | | | 1.637 | | | 4.011 | | | | 5.775 | 7.865 | | |
| 最大值 | 0.736 | | | 1.681 | | | | | 4.236 | | | | | 6.068 | | | | | 8.16 | | | 最大值 | | 0.768 | | | 1.668 | | | 4.121 | | | | 5.842 | 7.925 | | |
| Gmin | 1.400 | | | 0.957 | | | | | 1.015 | | | | | 1.171 | | | | | 1.376 | | | Gmin | | 1.560 | | | 1.176 | | | 1.462 | | | | 1.018 | 1.384 | | |
| Gmax | 1.200 | | | 1.565 | | | | | 1.853 | | | | | 1.634 | | | | | 1.282 | | | Gmax | | 1.400 | | | 1.429 | | | 1.410 | | | | 1.418 | 1.295 | | |
| 实验室5 | Al203 | | | | | | | | | | | | | | | | | | | | | 实验室6 | |  | | | | | | | | | | | | | |
| 样品  编号 | 6 | 5 | | | | | 1 | | | | | 3 | | | | | 2 | | | | | 样品  编号 | | 6 | | 5 | | | 1 | | | | 3 | | | 2 | |
| 样品测定结果，% | 0.657 | 1.674 | | | | | 3.962 | | | | | 5.675 | | | | | 7.783 | | | | | 样品测定结果，% | | 0.714 | | 1.640 | | | 4.109 | | | | 5.840 | | | 8.055 | |
| 0.675 | 1.645 | | | | | 3.985 | | | | | 5.785 | | | | | 7.908 | | | | | 0.716 | | 1.625 | | | 4.068 | | | | 5.908 | | | 8.053 | |
| 0.686 | 1.656 | | | | | 4.070 | | | | | 5.741 | | | | | 7.753 | | | | | 0.715 | | 1.649 | | | 4.108 | | | | 5.860 | | | 8.090 | |
| 0.691 | 1.655 | | | | | 4.088 | | | | | 5.765 | | | | | 7.707 | | | | | 0.742 | | 1.640 | | | 4.110 | | | | 5.883 | | | 8.097 | |
| 0.708 | 1.657 | | | | | 4.034 | | | | | 5.728 | | | | | 7.774 | | | | | 0.730 | | 1.639 | | | 4.115 | | | | 5.921 | | | 7.992 | |
| 0.648 | 1.663 | | | | | 4.000 | | | | | 5.795 | | | | | 7.821 | | | | | 0.694 | | 1.638 | | | 4.111 | | | | 5.988 | | | 8.027 | |
| 0.657 | 1.664 | | | | | 4.040 | | | | | 5.839 | | | | | 7.780 | | | | | 0.702 | | 1.640 | | | 4.114 | | | | 5.916 | | | 8.056 | |
| 平均值/% | 0.675 | 1.659 | | | | | 4.026 | | | | | 5.761 | | | | | 7.789 | | | | | 平均值/% | | 0.716 | | 1.639 | | | 4.105 | | | | 5.902 | | | 8.053 | |
| s/% | 0.0218 | 0.009 | | | | | 0.0456 | | | | | 0.0528 | | | | | 0.0626 | | | | | s/% | | 0.0149 | | 0.0065 | | | 0.0153 | | | | 0.04465 | | | 0.0332 | |
| RSD/% | 3.23 | 0.55 | | | | | 1.13 | | | | | 0.92 | | | | | 0.8 | | | | | RSD/% | | 2.08 | | 0.40 | | | 0.37 | | | | 0.76 | | | 0.41 | |
| 最小值 | 0.648 | 1.645 | | | | | 3.962 | | | | | 5.675 | | | | | 7.707 | | | | | 最小值 | | 0.694 | | 1.625 | | | 4.068 | | | | 5.84 | | | 7.992 | |
| 最大值 | 0.708 | 1.674 | | | | | 4.088 | | | | | 5.839 | | | | | 7.908 | | | | | 最大值 | | 0.742 | | 1.649 | | | 4.115 | | | | 5.988 | | | 8.097 | |
| Gmin | 1.239 | 1.556 | | | | | 1.404 | | | | | 1.629 | | | | | 1.310 | | | | | Gmin | | 1.477 | | 2.154 | | | 2.418 | | | | 1.389 | | | 1.837 | |
| Gmax | 1.514 | 1.667 | | | | | 1.360 | | | | | 1.477 | | | | | 1.901 | | | | | Gmax | | 1.745 | | 1.538 | | | 0.654 | | | | 1.926 | | | 1.325 | |
| 实验室7 | Al203 | | | | | | | | | | | | | | | | | | | | | 实验室8 | | Al203 | | | | | | | | | | | | | |
| 样品  编号 | 6 | | | 5 | | | | | 1 | | | | | 3 | | | | | 2 | | | 样品  编号 | | 6 | | 5 | | | 1 | | | | 3 | | | 2 | |
| 样品测定结果，% | 0.701 | | | 1.621 | | | | | 4.035 | | | | | 5.929 | | | | | 7.944 | | | 样品测定结果，% | | 0.712 | | 1.643 | | | 4.209 | | | | 6.090 | | | 7.939 | |
| 0.725 | | | 1.628 | | | | | 4.098 | | | | | 5.843 | | | | | 8.078 | | | 0.684 | | 1.587 | | | 4.236 | | | | 6.142 | | | 8.230 | |
| 0.714 | | | 1.596 | | | | | 4.132 | | | | | 5.889 | | | | | 8.065 | | | 0.693 | | 1.627 | | | 4.057 | | | | 6.036 | | | 7.988 | |
| 0.702 | | | 1.635 | | | | | 4.056 | | | | | 5.926 | | | | | 8.127 | | | 0.708 | | 1.665 | | | 4.039 | | | | 6.012 | | | 8.105 | |
| 0.700 | | | 1.604 | | | | | 4.074 | | | | | 5.941 | | | | | 8.004 | | | 0.741 | | 1.598 | | | 4.212 | | | | 5.945 | | | 8.184 | |
| 0.698 | | | 1.632 | | | | | 4.096 | | | | | 5.869 | | | | | 8.168 | | | 0.735 | | 1.634 | | | 4.025 | | | | 6.107 | | | 8.067 | |
| 0.719 | | | 1.599 | | | | | 4.126 | | | | | 5.982 | | | | | 8.121 | | | 0.711 | | 1.607 | | | 4.221 | | | | 6.008 | | | 8.082 | |
| 平均值/% | 0.708 | | | 1.616 | | | | | 4.088 | | | | | 5.911 | | | | | 8.072 | | | 平均值/% | | 0.712 | | 1.623 | | | 4.143 | | | | 6.049 | | | 8.085 | |
| s/% | 0.0108 | | | 0.0164 | | | | | 0.0355 | | | | | 0.0472 | | | | | 0.0772 | | | s/% | | 0.0205 | | 0.0273 | | | 0.0966 | | | | 0.068 | | | 0.1019 | |
| RSD/% | 1.52 | | | 1.02 | | | | | 0.87 | | | | | 0.8 | | | | | 0.96 | | | RSD/% | | 2.89 | | 1.68 | | | 2.33 | | | | 1.12 | | | 1.26 | |
| 最小值 | 0.698 | | | 1.596 | | | | | 4.035 | | | | | 5.843 | | | | | 7.944 | | | 最小值 | | 0.684 | | 1.587 | | | 4.025 | | | | 5.945 | | | 7.939 | |
| 最大值 | 0.725 | | | 1.635 | | | | | 4.132 | | | | | 5.982 | | | | | 8.168 | | | 最大值 | | 0.741 | | 1.665 | | | 4.236 | | | | 6.142 | | | 8.23 | |
| Gmin | 0.926 | | | 1.220 | | | | | 1.493 | | | | | 1.441 | | | | | 1.658 | | | Gmin | | 1.366 | | 1.319 | | | 1.222 | | | | 1.529 | | | 1.433 | |
| Gmax | 1.574 | | | 1.159 | | | | | 1.239 | | | | | 1.504 | | | | | 1.244 | | | Gmax | | 1.415 | | 1.538 | | | 0.963 | | | | 1.368 | | | 1.423 | |
| 实验室9 | Al203 | | | | | | | | | | | | | | | | | | | | | 实验室10 | | Al203 | | | | | | | | | | | | | |
| 样品  编号 | 6 | | | 5 | | | | | 1 | | | | | 3 | | | | | 2 | | | 样品  编号 | | 6 | 5 | | | 1 | | | | | 3 | | | | 2 |
| 样品测定结果，% | 0.675 | | | 1 592 | | | | | 4.236 | | | | | 5.906 | | | | | 8.295 | | | 样品测定结果，% | | 0.764 | 1.684 | | | 4.21 | | | | | 6.132 | | | | 8.185 |
| 0.699 | | | 1.571 | | | | | 4.212 | | | | | 6.061 | | | | | 8.197 | | | 0.728 | 1.654 | | | 4.27 | | | | | 5.918 | | | | 8.312 |
| 0.698 | | | 1.670 | | | | | 4.066 | | | | | 6.146 | | | | | 7.979 | | | 0.678 | 1.562 | | | 4.13 | | | | | 6.062 | | | | 7.964 |
| 0.672 | | | 1.638 | | | | | 4.051 | | | | | 5.946 | | | | | 7.953 | | | 0.692 | 1.581 | | | 4.02 | | | | | 6.028 | | | | 8.257 |
| 0.710 | | | 1.687 | | | | | 4.040 | | | | | 6.006 | | | | | 8.193 | | | 0.75 | 1.597 | | | 4.09 | | | | | 6.119 | | | | 8.067 |
| 0.709 | | | 1.673 | | | | | 4.019 | | | | | 5.965 | | | | | 7.902 | | | 0.708 | 1.671 | | | 4.18 | | | | | 5.976 | | | | 8.00 |
| 0.724 | | | 1.706 | | | | | 4.000 | | | | | 6.029 | | | | | 7.998 | | | 0.712 | 1.623 | | | 4.22 | | | | | 5.93 | | | | 8.132 |
| 平均值/% | 0.698 | | | 1.648 | | | | | 4.089 | | | | | 6.008 | | | | | 8.074 | | | 平均值/% | | 0.719 | 1.625 | | | 4.159 | | | | | 6.024 | | | | 8.13 |
| s/% | 0.0189 | | | 0.0503 | | | | | 0.0948 | | | | | 0.0800 | | | | | 0.1512 | | | s/% | | 0.030678 | 0.046779 | | | 0.08479 | | | | | 0.085429 | | | | 0.130232 |
| RSD/% | 2.71 | | | 3.05 | | | | | 2.32 | | | | | 1.33 | | | | | 1.87 | | | RSD/% | | 4.27 | 2.88 | | | 2.04 | | | | | 1.42 | | | | 1.61 |
| 最小值 | 0.672 | | | 1.571 | | | | | 4 | | | | | 5.906 | | | | | 7.902 | | | 最小值 | | 0.678 | 1.581 | | | 4.021 | | | | | 5.918 | | | | 7.964 |
| 最大值 | 0.724 | | | 1.706 | | | | | 4.236 | | | | | 6.146 | | | | | 8.295 | | | 最大值 | | 0.75 | 1.684 | | | 4.267 | | | | | 6.132 | | | | 8.312 |
| Gmin | 1.376 | | | 1.531 | | | | | 0.939 | | | | | 1.275 | | | | | 1.138 | | | Gmin | | 1.336 | 0.941 | | | 1.628 | | | | | 1.241 | | | | 1.275 |
| Gmax | 1.376 | | | 1.153 | | | | | 1.551 | | | | | 1.725 | | | | | 1.462 | | | Gmax | | 1.010 | 1.261 | | | 1.274 | | | | | 1.264 | | | | 1.398 |
| 实验室11 | Al203 | | | | | | | | | | | | | | | | | | | | | 实验室12 | | Al203 | | | | | | | | | | | | | |
| 样品编号 | 6 | | | 5 | | | | | 1 | | | | | 3 | | | | | 2 | | | 样品编号 | | 6 | | 5 | | | 1 | | | | 3 | | | 2 | |
| 样品测定结果，% | 0.697 | | | 1.609 | | | | | 4.245 | | | | | 6.029 | | | | | 8.401 | | | 样品测定结果，% | | 0.680 | | 1.554 | | | 4.004 | | | | 6.139 | | | 8.019 | |
| 0.695 | | | 1.672 | | | | | 4.213 | | | | | 5.976 | | | | | 8.227 | | | 0.668 | | 1.612 | | | 4.046 | | | | 5.998 | | | 8.144 | |
| 0.713 | | | 1.711 | | | | | 4.271 | | | | | 6.097 | | | | | 8.172 | | | 0.686 | | 1.672 | | | 4.106 | | | | 5.979 | | | 7.943 | |
| 0.668 | | | 1.610 | | | | | 4.115 | | | | | 6.069 | | | | | 8.317 | | | 0.633 | | 1.629 | | | 4.078 | | | | 6.113 | | | 8.048 | |
| 0.710 | | | 1.689 | | | | | 4.302 | | | | | 6.048 | | | | | 7.995 | | | 0.690 | | 1.625 | | | 4.043 | | | | 6.066 | | | 7.982 | |
| 0.724 | | | 1.675 | | | | | 4.201 | | | | | 5.908 | | | | | 8.299 | | | 0.687 | | 1.616 | | | 4.056 | | | | 5.952 | | | 8.020 | |
| 0.750 | | | 1.710 | | | | | 4.129 | | | | | 6.123 | | | | | 8.096 | | | 0.707 | | 1.625 | | | 4.137 | | | | 5.923 | | | 8.074 | |
| 平均值/% | 0.708 | | | 1.668 | | | | | 4.211 | | | | | 6.036 | | | | | 8.215 | | | 平均值/% | | 0.679 | | 1.619 | | | 4.067 | | | | 6.024 | | | 8.033 | |
| s/% | 0.0256 | | | 0.0427 | | | | | 0.0696 | | | | | 0.0737 | | | | | 0.1394 | | | s/% | | 0.023 | | 0.035 | | | 0.044 | | | | 0.083 | | | 0.065 | |
| RSD/% | 3.62 | | | 2.56 | | | | | 1.65 | | | | | 1.22 | | | | | 1.7 | | | RSD/% | | 3.432 | | 2.149 | | | 1.083 | | | | 1.372 | | | 0.808 | |
| 最小值 | 0.668 | | | 1.609 | | | | | 4.115 | | | | | 5.908 | | | | | 7.995 | | | 最小值 | | 0.633 | | 1.554 | | | 4.004 | | | | 5.923 | | | 7.943 | |
| 最大值 | 0.75 | | | 1.711 | | | | | 4.302 | | | | | 6.123 | | | | | 8.401 | | | 最大值 | | 0.707 | | 1.672 | | | 4.137 | | | | 6.139 | | | 8.144 | |
| Gmin | 1.563 | | | 1.382 | | | | | 1.379 | | | | | 1.737 | | | | | 1.578 | | | Gmin | | 2.000 | | 1.857 | | | 1.432 | | | | 1.217 | | | 1.385 | |
| Gmax | 1.641 | | | 1.007 | | | | | 1.307 | | | | | 1.180 | | | | | 1.334 | | | Gmax | | 1.217 | | 1.514 | | | 1.591 | | | | 1.386 | | | 1.708 | |
| 实验室13 | Al203 | | | | | | | | | | | | | | | | | | | | | 实验室14 | | Al203 | | | | | | | | | | | | | |
| 样品编号 | 6 | | | | | 5 | | | | | 1 | | | | | 3 | | | | | 2 | 样品编号 | | 6 | | 5 | | | 1 | | | | 3 | | | 2 | |
| 样品测定结果，% | 0.708 | | | | | 1.559 | | | | | 4.165 | | | | | 5.813 | | | | | 8.081 | 样品测定结果，% | | 0.689 | | 1.666 | | | 4.077 | | | | 6.052 | | | 7.976 | |
| 0.715 | | | | | 1.434 | | | | | 4.121 | | | | | 6.131 | | | | | 7.924 | 0.726 | | 1.624 | | | 4.018 | | | | 6.226 | | | 8.186 | |
| 0.718 | | | | | 1.587 | | | | | 4.019 | | | | | 6.052 | | | | | 8.045 | 0.692 | | 1.616 | | | 4.144 | | | | 6.106 | | | 8.075 | |
| 0.651 | | | | | 1.538 | | | | | 4.087 | | | | | 5.914 | | | | | 7.922 | 0.684 | | 1.675 | | | 4.083 | | | | 6.087 | | | 8.237 | |
| 0.712 | | | | | 1.575 | | | | | 4.072 | | | | | 5.901 | | | | | 7.872 | 0.721 | | 1.583 | | | 4.150 | | | | 6.045 | | | 8.156 | |
| 0.699 | | | | | 1.524 | | | | | 4.115 | | | | | 5.934 | | | | | 7.891 | 0.713 | | 1.635 | | | 4.119 | | | | 5.948 | | | 8.115 | |
| 0.683 | | | | | 1.538 | | | | | 4.128 | | | | | 5.873 | | | | | 7.995 | 0.701 | | 1.645 | | | 4.189 | | | | 6.145 | | | 8.066 | |
| 平均值/% | 0.698 | | | | | 1.536 | | | | | 4.101 | | | | | 5.945 | | | | | 7.961 | 平均值/% | | 0.704 | | 1.635 | | | 4.112 | | | | 6.087 | | | 8.116 | |
| s/% | 0.024 | | | | | 0.050 | | | | | 0.047 | | | | | 0.109 | | | | | 0.080 | s/% | | 0.0165 | | 0.0312 | | | 0.0567 | | | | 0.087 | | | 0.0865 | |
| RSD/% | 3.420 | | | | | 3.277 | | | | | 1.143 | | | | | 1.838 | | | | | 1.004 | RSD/% | | 2.34 | | 1.91 | | | 1.38 | | | | 1.43 | | | 1.07 | |
| 最小值 | 0.651 | | | | | 1.434 | | | | | 4.019 | | | | | 5.813 | | | | | 7.872 | 最小值 | | 0.684 | | 1.583 | | | 4.018 | | | | 5.948 | | | 7.976 | |
| 最大值 | 0.718 | | | | | 1.587 | | | | | 4.165 | | | | | 6.131 | | | | | 8.081 | 最大值 | | 0.726 | | 1.675 | | | 4.189 | | | | 6.226 | | | 8.237 | |
| Gmin | 1.969 | | | | | 2.026 | | | | | 1.749 | | | | | 1.208 | | | | | 1.114 | Gmin | | 1.212 | | 1.667 | | | 1.658 | | | | 1.598 | | | 1.618 | |
| Gmax | 0.838 | | | | | 1.013 | | | | | 1.365 | | | | | 1.702 | | | | | 1.502 | Gmax | | 1.333 | | 1.282 | | | 1.358 | | | | 1.598 | | | 1.399 | |
| 实验室15 | Al203 | | | | | | | | | | | | | | | | | | | | | 实验室16 | | Al203 | | | | | | | | | | | | | |
| 样品编号 | 6 | | 5 | | | | | 1 | | | | | 3 | | | | | 2 | | | | 样品编号 | | **6** | | **5** | | | **1** | | | **3** | | | | **2** | |
| 样品测定结果，% | 0.682 | | 1.557 | | | | | 4.021 | | | | | 5.859 | | | | | 7.615 | | | | 样品测定结果，% | | 0.692 | | 1.652 | | | 4.022 | | | 5.893 | | | | 7.913 | |
| 0.692 | | 1.583 | | | | | 3.838 | | | | | 5.756 | | | | | 7.960 | | | | 0.707 | | 1.643 | | | 4.039 | | | 5.950 | | | | 7.949 | |
| 0.653 | | 1.592 | | | | | 3.942 | | | | | 5.834 | | | | | 7.803 | | | | 0.692 | | 1.632 | | | 4.069 | | | 5.848 | | | | 7.912 | |
| 0.702 | | 1.575 | | | | | 3.895 | | | | | 5.884 | | | | | 7.805 | | | | 0.699 | | 1.636 | | | 4.045 | | | 5.871 | | | | 8.009 | |
| 0.682 | | 1.582 | | | | | 3.917 | | | | | 5.842 | | | | | 7.762 | | | | 0.713 | | 1.645 | | | 4.022 | | | 5.859 | | | | 7.955 | |
| 0.679 | | 1.574 | | | | | 3.935 | | | | | 5.685 | | | | | 7.613 | | | | 0.692 | | 1.635 | | | 4.017 | | | 5.923 | | | | 8.068 | |
| 0.669 | | 1.622 | | | | | 3.867 | | | | | 5.962 | | | | | 7.781 | | | | 0.695 | | ~~1.695~~ | | | 4.091 | | | 5.943 | | | | 8.044 | |
| 平均值/% | 0.680 | | 1.584 | | | | | 3.916 | | | | | 5.832 | | | | | 7.763 | | | | 平均值/% | | 0.699 | | 1.648 | | | 4.044 | | | 5.898 | | | | 7.979 | |
| s/% | 0.0157 | | 0.0201 | | | | | 0.0591 | | | | | 0.0893 | | | | | 0.1203 | | | | s/% | | 0.0084 | | 0.0217 | | | 0.0276 | | | 0.0411 | | | | 0.0624 | |
| RSD/% | 2.32 | | 1.27 | | | | | 1.51 | | | | | 1.53 | | | | | 1.55 | | | | RSD/% | | 1.2 | | 1.32 | | | 0.681 | | | 0.697 | | | | 0.782 | |
| 最小值 | 0.653 | | 1.557 | | | | | 3.838 | | | | | 5.685 | | | | | 7.613 | | | | 最小值 | | 0.692 | | 1.632 | | | 4.017 | | | 5.848 | | | | 7.912 | |
| 最大值 | 0.702 | | 1.622 | | | | | 4.021 | | | | | 5.962 | | | | | 7.96 | | | | 最大值 | | 0.713 | | 1.695 | | | 4.091 | | | 5.95 | | | | 8.068 | |
| Gmin | 1.720 | | 1.343 | | | | | 1.320 | | | | | 1.646 | | | | | 1.247 | | | | Gmin | | 0.833 | | 0.737 | | | 0.978 | | | 1.217 | | | | 1.074 | |
| Gmax | 1.401 | | 1.891 | | | | | 1.777 | | | | | 1.456 | | | | | 1.638 | | | | Gmax | | 1.667 | | 2.166 | | | 1.703 | | | 1.265 | | | | 1.426 | |
| 实验室17 | Al203 | | | | | | | | | | | | | | | | | | | | | 实验室18 | | Al203 | | | | | | | | | | | | | |
| 样品编号 | **6** | | | **5** | | | | | **1** | | | | | **3** | | | | | **2** | | | 样品编号 | | 6 | 5 | | | 1 | | | 3 | | | | | | 2 |
| 样品测定结果，% | 0.715 | | | 1.678 | | | | | 4.025 | | | | | 5.876 | | | | | 7.895 | | | 样品测定结果，% | | 0.721 | 1.642 | | | 4.112 | | | 5.988 | | | | | | 8.098 |
| 0.707 | | | 1.621 | | | | | 4.021 | | | | | 5.963 | | | | | 7.923 | | | 0.697 | 1.592 | | | 4.158 | | | 6.045 | | | | | | 8.127 |
| 0.672 | | | 1.653 | | | | | 4.056 | | | | | 5.842 | | | | | 7.917 | | | 0.744 | 1.621 | | | 4.059 | | | 6.011 | | | | | | 8.088 |
| 0.693 | | | 1.668 | | | | | 4.051 | | | | | 5.849 | | | | | 8.043 | | | 0.685 | 1.651 | | | 4.015 | | | 5.907 | | | | | | 7.962 |
| 0.685 | | | 1.637 | | | | | 4.018 | | | | | 5.882 | | | | | 7.892 | | | 0.694 | 1.627 | | | 4.148 | | | 5.963 | | | | | | 8.138 |
| 0.691 | | | 1.659 | | | | | 4.085 | | | | | 5.855 | | | | | 7.954 | | | 0.753 | 1.637 | | | 4.237 | | | 6.134 | | | | | | 8.234 |
| 0.684 | | | 1.572 | | | | | 4.074 | | | | | 5.834 | | | | | 7.921 | | | 0.739 | 1.633 | | | 4.192 | | | 6.129 | | | | | | 7.982 |
| 平均值/% | 0.692 | | | 1.641 | | | | | 4.047 | | | | | 5.872 | | | | | 7.935 | | | 平均值/% | | 0.719 | 1.629 | | | 4.132 | | | 6.025 | | | | | | 8.090 |
| s/% | 0.0145 | | | 0.0359 | | | | | 0.0267 | | | | | 0.0439 | | | | | 0.0519 | | | s/% | | 0.0272 | 0.019 | | | 0.0763 | | | 0.0841 | | | | | | 0.0936 |
| RSD/% | 2.099 | | | 2.189 | | | | | 0.659 | | | | | 0.747 | | | | | 0.654 | | | RSD/% | | 3.79 | 1.17 | | | 1.85 | | | 1.4 | | | | | | 1.16 |
| 最小值 | 0.672 | | | 1.572 | | | | | 4.018 | | | | | 5.834 | | | | | 7.892 | | | 最小值 | | 0.685 | 1.592 | | | 4.015 | | | 5.907 | | | | | | 7.962 |
| 最大值 | 0.715 | | | 1.678 | | | | | 4.085 | | | | | 5.963 | | | | | 8.043 | | | 最大值 | | 0.753 | 1.651 | | | 4.237 | | | 6.134 | | | | | | 8.234 |
| Gmin | 1.379 | | | 1.922 | | | | | 1.086 | | | | | 0.866 | | | | | 0.829 | | | Gmin | | 1.250 | 1.947 | | | 1.533 | | | 1.403 | | | | | | 1.368 |
| Gmax | 1.586 | | | 1.031 | | | | | 1.423 | | | | | 2.073 | | | | | 2.081 | | | Gmax | | 1.250 | 1.158 | | | 1.376 | | | 1.296 | | | | | | 1.538 |
| 实验室19 | Al203 | | | | | | | | | | | | | | | | | | | | | |
| 样品编号 | 6 | | | | 5 | | | | | 1 | | | | | 3 | | | | | 2 | | |
| 样品测定结果，% | 0.699 | | | | 1.634 | | | | | 4.118 | | | | | 6.016 | | | | | 7.965 | | |
| 0.756 | | | | 1.558 | | | | | 4.250 | | | | | 5.903 | | | | | 8.245 | | |
| 0.708 | | | | 1.577 | | | | | 4.061 | | | | | 6.044 | | | | | 7.952 | | |
| 0.727 | | | | 1.672 | | | | | 4.137 | | | | | 5.941 | | | | | 8.054 | | |
| 0.680 | | | | 1.653 | | | | | 4.156 | | | | | 5.988 | | | | | 8.198 | | |
| 0.718 | | | | 1.662 | | | | | 4.014 | | | | | 6.158 | | | | | 8.094 | | |
| 0.737 | | | | 1.643 | | | | | 4.193 | | | | | 6.124 | | | | | 8.132 | | |
| 平均值/% | 0.718 | | | | 1.628 | | | | | 4.133 | | | | | 6.025 | | | | | 8.091 | | |
| s/% | 0.025 | | | | 0.0436 | | | | | 0.079 | | | | | 0.0925 | | | | | 0.1104 | | |
| RSD/% | 3.48 | | | | 2.68 | | | | | 1.91 | | | | | 1.53 | | | | | 1.36 | | |
| 最小值 | 0.68 | | | | 1.558 | | | | | 4.014 | | | | | 5.903 | | | | | 7.952 | | |
| 最大值 | 0.756 | | | | 1.672 | | | | | 4.25 | | | | | 6.158 | | | | | 8.245 | | |
| Gmin | 1.520 | | | | 1.606 | | | | | 1.506 | | | | | 1.319 | | | | | 1.259 | | |
| Gmax | 1.520 | | | | 1.009 | | | | | 1.481 | | | | | 1.438 | | | | | 1.395 | | |

结果表明：实验室16的样品5有离群值，剔除。

**3、一致性和离群检验。**

**3.1曼德尔h-k检验**

3.1.1对各实验室提供的铬数据进行曼德尔h-k检验，检验结果分别见表3-1、表3-2。

表3-1 曼德尔h统计量的值

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 实验室 | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 | 水平6 |
| 1 | -0.2778 | -0.4000 | 0.7914 | 0.1342 | 0.1606 | 0.8262 |
| 2 | -0.5556 | -0.4000 | 0.1439 | 0.7047 | 0.3899 | 0.4475 |
| 3 | -1.3889 | -0.6667 | -1.0072 | 0.2685 | 0.4358 | 0.4991 |
| 4 | 0.5556 | -0.2667 | -0.0719 | -0.1678 | 0.2523 | 0.1721 |
| 5 | 0.8333 | -1.6000 | -0.0719 | -1.1745 | 0.1835 | -0.0861 |
| 6 | -0.8333 | 0.4000 | 0.6475 | 0.7383 | 0.5963 | 0.2754 |
| 7 | -0.2778 | 1.8667 | 0.9353 | 0.5034 | -0.2064 | -0.2065 |
| 8 | -0.5556 | -0.1333 | 0.2158 | 0.6376 | 0.1606 | 0.4303 |
| 9 | -0.2778 | 0.2667 | 0.0000 | -0.0671 | 0.4587 | -0.0688 |
| 10 | 0.0000 | -0.2667 | 0.8633 | 0.5369 | 1.5596 | 0.9294 |
| 11 | -0.5556 | 0.8000 | 1.1511 | 2.1812 | 0.8257 | 1.2909 |
| 12 | -1.3889 | -1.2000 | -2.0863 | -1.3423 | 1.1468 | 1.3081 |
| 13 | 0.8333 | 1.0667 | -1.0072 | 0.4554 | -1.9725 | -2.3408 |
| 14 | -0.5556 | -0.2667 | -1.5827 | -0.8389 | 0.1606 | -0.0688 |
| 15 | 0.2778 | -1.4667 | -1.5827 | -2.4832 | -2.5459 | -2.0826 |
| 16 | 2.2222 | 1.6000 | 1.1511 | -0.2685 | -0.8945 | -0.9466 |
| 17 | 2.2222 | 1.7333 | 1.0072 | -0.5705 | -1.0780 | -1.1188 |
| 18 | -0.5556 | -0.1333 | 0.2878 | 0.5705 | 0.2294 | 0.3787 |
| 19 | -0.5556 | -0.1333 | 0.3597 | 0.4362 | 0.1376 | 0.3959 |
| h临界值：p=19，显著性水平为1%时h=2.37，显著性水平5%时h=1.88 | | | | | | |

结果表明：实验室15的水平4和水平5的数据为离群值，剔除离群值。

表3-2 曼德尔k统计量的值

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 实验室 | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 | 水平6 |
| 1 | 0.8460 | 1.1028 | 1.1848 | 1.7469 | 0.8006 | 1.5305 |
| 2 | 0.7131 | 1.0112 | 0.4938 | 0.4460 | 0.3251 | 0.7935 |
| 3 | 0.6510 | 0.5783 | 1.1389 | 0.4373 | 0.6096 | 1.1496 |
| 4 | 1.1625 | 1.1136 | 1.4842 | 1.3268 | 0.7957 | 0.2976 |
| 5 | 2.3791 | 1.7400 | 1.0608 | 0.8906 | 0.9841 | 0.3606 |
| 6 | 0.5403 | 0.8841 | 0.8062 | 0.5799 | 0.3601 | 0.5726 |
| 7 | 0.4754 | 0.4008 | 0.4643 | 0.5690 | 0.7718 | 0.3412 |
| 8 | 0.6138 | 0.6655 | 1.1328 | 1.2883 | 0.5137 | 0.9216 |
| 9 | 0.4704 | 0.9368 | 0.3873 | 1.3740 | 0.5645 | 0.9597 |
| 10 | 1.7292 | 1.4736 | 1.5117 | 1.3005 | 2.8580 | 1.7544 |
| 11 | 0.8788 | 1.3627 | 1.1295 | 1.4393 | 1.4549 | 2.2577 |
| 12 | 0.7479 | 0.4595 | 0.4498 | 0.3603 | 0.8542 | 0.5223 |
| 13 | 1.0407 | 0.8943 | 0.7175 | 0.4060 | 1.0087 | 0.6689 |
| 14 | 0.8206 | 0.8560 | 1.1155 | 0.8250 | 0.7834 | 0.9508 |
| 15 | 1.0270 | 0.7764 | 1.0603 | 1.1341 | 0.7557 | 0.5485 |
| 16 | 0.5271 | 0.9158 | 0.4341 | 0.6662 | 0.4821 | 0.4745 |
| 17 | 0.8788 | 1.0140 | 0.5226 | 0.3679 | 0.3318 | 0.2631 |
| 18 | 0.6252 | 0.7742 | 1.2715 | 0.8071 | 0.7647 | 0.9689 |
| 19 | 0.8061 | 1.0266 | 1.3075 | 1.2447 | 0.9116 | 0.9706 |
| k临界值：p=19，n=7，显著性水平为1%时k=1.64，显著性水平5%时k=1.43 | | | | | | |

结果表明：实验室1的水平4、实验室5的水平1和水平2、实验室10的水平1和水平6、实验室11的水平6的数据，为离群值，剔除离群值。

3.1.2对各实验室提供的氧化铝数据进行曼德尔h-k检验，检验结果分别见表3-3、表3-4。

表3-3 曼德尔h统计量的值

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 实验室 | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 |
| 1 | 0.2683 | -0.8398 | -0.1682 | 0.8656 | 0.0035 |
| 2 | 0.6610 | -0.3359 | 0.5013 | 1.1741 | 0.8873 |
| 3 | 0.4647 | 0.6046 | 0.2890 | 0.3722 | 0.2201 |
| 4 | 1.8390 | 0.8062 | -0.4131 | -1.6634 | -1.1231 |
| 5 | -1.9568 | 1.0749 | -1.0826 | -2.0952 | -2.0503 |
| 6 | 0.7264 | 0.4031 | 0.2074 | -0.6456 | 0.2374 |
| 7 | 0.2029 | -0.3695 | -0.0702 | -0.5531 | 0.4021 |
| 8 | 0.4647 | -0.1344 | 0.8279 | 0.8656 | 0.5147 |
| 9 | -0.4516 | 0.7054 | -0.0539 | 0.4441 | 0.4194 |
| 10 | 0.9228 | -0.0672 | 1.0892 | 0.6086 | 0.9047 |
| 11 | 0.2029 | 1.3772 | 1.9383 | 0.7320 | 1.6412 |
| 12 | -1.6950 | -0.2687 | -0.4131 | 0.6086 | 0.0641 |
| 13 | -0.4516 | -3.0568 | 0.1421 | -0.2036 | -0.5598 |
| 14 | -0.0589 | 0.2687 | 0.3217 | 1.2563 | 0.7834 |
| 15 | -1.6296 | -1.4444 | -2.8788 | -1.3653 | -2.2756 |
| 16 | -0.3861 | 0.7054 | -0.7887 | -0.6867 | -0.4038 |
| 17 | -0.8442 | 0.4703 | -0.7397 | -0.9540 | -0.7851 |
| 18 | 0.9228 | 0.0672 | 0.6483 | 0.6189 | 0.5581 |
| 19 | 0.8573 | 0.0336 | 0.6646 | 0.6189 | 0.5667 |
| h临界值：p=19，显著性水平为1%时h=2.37，显著性水平5%时h=1.88 | | | | | |

结果表明：实验室13的水平2、实验室15的水平3数据，为离群值，剔除。

表3-4 曼德尔k统计量的值

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 实验室 | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 |
| 1 | 0.6781 | 0.7842 | 0.6319 | 1.5261 | 1.2258 |
| 2 | 0.8274 | 0.7028 | 1.0366 | 0.7283 | 0.9124 |
| 3 | 0.9640 | 0.7338 | 1.1281 | 0.5524 | 0.8964 |
| 4 | 1.1870 | 0.3747 | 0.6321 | 0.3751 | 0.2376 |
| 5 | 1.0334 | 0.2838 | 0.7521 | 0.7188 | 0.6634 |
| 6 | 0.7649 | 0.2217 | 0.2722 | 0.6568 | 0.3797 |
| 7 | 0.5106 | 0.5152 | 0.5856 | 0.6427 | 0.8172 |
| 8 | 0.9754 | 0.8572 | 1.5922 | 0.9258 | 1.0790 |
| 9 | 0.8982 | 1.5036 | 1.5627 | 1.0894 | 1.6011 |
| 10 | 1.7173 | 1.7392 | 1.3976 | 1.1634 | 1.3791 |
| 11 | 1.2166 | 1.3413 | 1.1475 | 1.0031 | 1.4763 |
| 12 | 1.1060 | 1.0918 | 0.7263 | 1.1257 | 0.6876 |
| 13 | 1.1337 | 1.5796 | 0.7726 | 1.4884 | 0.8463 |
| 14 | 0.7830 | 0.9795 | 0.9359 | 1.1840 | 0.9163 |
| 15 | 0.7475 | 0.6304 | 0.9748 | 1.2158 | 1.2745 |
| 16 | 0.3981 | 0.6811 | 0.4542 | 0.5595 | 0.6609 |
| 17 | 0.6902 | 1.1272 | 0.4398 | 0.5977 | 0.5492 |
| 18 | 1.2931 | 0.5967 | 1.2584 | 1.1452 | 0.9908 |
| 19 | 1.1935 | 1.3724 | 1.3014 | 1.2585 | 1.1714 |
| k临界值：p=19，n=7，显著性水平为1%时k=1.64，显著性水平5%时k=1.43 | | | | | |

结果表明：实验室10的水平1和水平2为离群值，剔除离群值。

**3.2单元平均值的统计**

3.2.1 铬剔除离群值后的单元平均值见表3-5，单位为质量百分数（%）。

表3-5 铬的单元平均值

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 实验室 | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 | 水平6 |
| 1 | 0.046 | 0.168 | 0.795 |  | 1.989 | 4.052 |
| 2 | 0.045 | 0.168 | 0.786 | 1.140 | 1.999 | 4.030 |
| 3 | 0.042 | 0.166 | 0.770 | 1.127 | 2.001 | 4.033 |
| 4 | 0.049 | 0.169 | 0.783 | 1.114 | 1.993 | 4.014 |
| 5 |  |  | 0.783 | 1.084 | 1.990 | 3.999 |
| 6 | 0.044 | 0.174 | 0.793 | 1.141 | 2.008 | 4.020 |
| 7 | 0.046 | 0.185 | 0.797 | 1.134 | 1.973 | 3.992 |
| 8 | 0.045 | 0.170 | 0.787 | 1.138 | 1.989 | 4.029 |
| 9 | 0.046 | 0.173 | 0.784 | 1.117 | 2.002 | 4.000 |
| 10 |  | 0.169 | 0.796 | 1.135 | 2.050 |  |
| 11 | 0.045 | 0.177 | 0.800 | 1.184 | 2.018 |  |
| 12 | 0.042 | 0.162 | 0.755 | 1.079 | 2.032 | 4.080 |
| 13 | 0.050 | 0.179 | 0.770 | 1.133 | 1.896 | 3.868 |
| 14 | 0.045 | 0.169 | 0.762 | 1.094 | 1.989 | 4.000 |
| 15 | 0.048 | 0.160 | 0.762 |  |  | 3.883 |
| 16 | 0.055 | 0.183 | 0.800 | 1.111 | 1.943 | 3.949 |
| 17 | 0.055 | 0.184 | 0.798 | 1.102 | 1.935 | 3.939 |
| 18 | 0.045 | 0.170 | 0.788 | 1.136 | 1.992 | 4.026 |
| 19 | 0.045 | 0.170 | 0.789 | 1.132 | 1.988 | 4.027 |

3.2.2 氧化铝剔除离群值后的单元平均值见表3-6，单位为质量百分数（%）。

表3-6 氧化铝的单元平均值

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 实验室 | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 |
| 1 | 0.709 | 1.602 | 4.082 | 6.049 | 8.026 |
| 2 | 0.715 | 1.617 | 4.123 | 6.079 | 8.128 |
| 3 | 0.712 | 1.645 | 4.110 | 6.001 | 8.051 |
| 4 | 0.733 | 1.651 | 4.067 | 5.803 | 7.896 |
| 5 | 0.675 | 1.659 | 4.026 | 5.761 | 7.789 |
| 6 | 0.716 | 1.639 | 4.105 | 5.902 | 8.053 |
| 7 | 0.708 | 1.616 | 4.088 | 5.911 | 8.072 |
| 8 | 0.712 | 1.623 | 4.143 | 6.049 | 8.085 |
| 9 | 0.698 | 1.648 | 4.089 | 6.008 | 8.074 |
| 10 |  |  | 4.159 | 6.024 | 8.130 |
| 11 | 0.708 | 1.668 | 4.211 | 6.036 | 8.215 |
| 12 | 0.679 | 1.619 | 4.067 | 6.024 | 8.033 |
| 13 | 0.698 |  | 4.101 | 5.945 | 7.961 |
| 14 | 0.704 | 1.635 | 4.112 | 6.087 | 8.116 |
| 15 | 0.680 | 1.584 |  | 5.832 | 7.763 |
| 16 | 0.699 | 1.648 | 4.044 | 5.898 | 7.979 |
| 17 | 0.692 | 1.641 | 4.047 | 5.872 | 7.935 |
| 18 | 0.719 | 1.629 | 4.132 | 6.025 | 8.090 |
| 19 | 0.718 | 1.628 | 4.133 | 6.025 | 8.091 |

**3.3标准差的统计**

3.3.1 铬标准差的统计

表3-7 铬标准差的统计

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 实验室 | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 | 水平6 |
| 1 | 0.0027 | 0.0084 | 0.0175 |  | 0.0291 | 0.0966 |
| 2 | 0.0023 | 0.0077 | 0.0073 | 0.0075 | 0.0118 | 0.0501 |
| 3 | 0.0021 | 0.0044 | 0.0169 | 0.0074 | 0.0222 | 0.0726 |
| 4 | 0.0037 | 0.0084 | 0.0220 | 0.0224 | 0.0289 | 0.0188 |
| 5 |  |  | 0.0157 | 0.0150 | 0.0358 | 0.0228 |
| 6 | 0.0017 | 0.0067 | 0.0119 | 0.0098 | 0.0131 | 0.0362 |
| 7 | 0.0015 | 0.0030 | 0.0069 | 0.0096 | 0.0281 | 0.0215 |
| 8 | 0.0020 | 0.0050 | 0.0168 | 0.0217 | 0.0187 | 0.0582 |
| 9 | 0.0015 | 0.0071 | 0.0057 | 0.0232 | 0.0205 | 0.0606 |
| 10 |  | 0.0112 | 0.0224 | 0.0220 | 0.1040 |  |
| 11 | 0.0028 | 0.0103 | 0.0167 | 0.0243 | 0.0529 |  |
| 12 | 0.0024 | 0.0035 | 0.0067 | 0.0061 | 0.0311 | 0.0330 |
| 13 | 0.0033 | 0.0068 | 0.0106 | 0.0069 | 0.0367 | 0.0422 |
| 14 | 0.0026 | 0.0065 | 0.0165 | 0.0139 | 0.0285 | 0.0600 |
| 15 | 0.0033 | 0.0059 | 0.0157 |  |  | 0.0346 |
| 16 | 0.0017 | 0.0069 | 0.0064 | 0.0112 | 0.0175 | 0.0300 |
| 17 | 0.0028 | 0.0077 | 0.0077 | 0.0062 | 0.0121 | 0.0166 |
| 18 | 0.0020 | 0.0059 | 0.0188 | 0.0136 | 0.0278 | 0.0612 |
| 19 | 0.0026 | 0.0078 | 0.0194 | 0.0210 | 0.0332 | 0.0613 |

3.3.2 氧化铝标准差的统计

表3-7 氧化铝标准差的统计

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 实验室 | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 |
| 1 | 0.0143 | 0.0250 | 0.0383 | 0.1121 | 0.1157 |
| 2 | 0.0174 | 0.0224 | 0.0629 | 0.0535 | 0.0862 |
| 3 | 0.0203 | 0.0234 | 0.0684 | 0.0406 | 0.0846 |
| 4 | 0.0250 | 0.0119 | 0.0384 | 0.0275 | 0.0224 |
| 5 | 0.0218 | 0.0090 | 0.0456 | 0.0528 | 0.0626 |
| 6 | 0.0161 | 0.0071 | 0.0165 | 0.0482 | 0.0359 |
| 7 | 0.0108 | 0.0164 | 0.0355 | 0.0472 | 0.0772 |
| 8 | 0.0205 | 0.0273 | 0.0966 | 0.0680 | 0.1019 |
| 9 | 0.0189 | 0.0479 | 0.0948 | 0.0800 | 0.1512 |
| 10 |  |  | 0.0848 | 0.0854 | 0.1302 |
| 11 | 0.0256 | 0.0427 | 0.0696 | 0.0737 | 0.1394 |
| 12 | 0.0233 | 0.0348 | 0.0441 | 0.0827 | 0.0649 |
| 13 | 0.0239 |  | 0.0469 | 0.1093 | 0.0799 |
| 14 | 0.0165 | 0.0312 | 0.0568 | 0.0869 | 0.0865 |
| 15 | 0.0157 | 0.0201 |  | 0.0893 | 0.1203 |
| 16 | 0.0084 | 0.0217 | 0.0276 | 0.0411 | 0.0624 |
| 17 | 0.0145 | 0.0359 | 0.0267 | 0.0439 | 0.0519 |
| 18 | 0.0272 | 0.0190 | 0.0763 | 0.0841 | 0.0936 |
| 19 | 0.0251 | 0.0437 | 0.0790 | 0.0924 | 0.1106 |

**3.4科克伦检验**

对n=7，p=12，科克伦检验临界值表中并未给出，但n=6，p=19，科克伦检验5%临界值为0.181，1%临界值为0.214。

铬：

对水平1，实验室4的s最大，检验统计量值=0.130

对水平2，实验室10的s最大，检验统计量值=0.137

对水平3，实验室10的s最大，检验统计量值=0.120

对水平4，实验室11的s最大，检验统计量值=0.141

对水平5，实验室10的s最大，检验统计量值=0.443>0.214

对水平6，实验室1的s最大，检验统计量值=0.0966

实验室10的水平5数据离群，剔除，再次进行柯克伦检验：

对水平5，实验室11的s最大，检验统计量值=0.206<0.214，表明没有离群值，所有数据参与后续计算。

氧化铝：

对水平1，实验室18的s最大，检验统计量值=0.104

对水平2，实验室9的s最大，检验统计量值=0.167

对水平3，实验室8的s最大，检验统计量值=0.140

对水平4，实验室1的s最大，检验统计量值=0.123

对水平5，实验室1的s最大，检验统计量值=0.135

均小于0.214.没有离群值，所有数据参与后续计算。

**3.5格拉布斯检验**

将格拉布斯检验应用于单元平均值，当p=19时，格拉布斯检验单个值上1%临界值为2.968，单个值上5%临界值为2.681；双值下1%临界值为0.3398，双值下5%临界值为0.4214。当p=18时，格拉布斯检验单个值上1%临界值为2.932，单个值上5%临界值为2.651；双值下1%临界值为0.3200，双值下5%临界值为0.4025。

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Cr | | | | | | | | | | | |
| 统计量 | 水平1 | 水平2 | | 水平3 | | 水平4 | | 水平5 | | 水平6 | |
| 单个低值 | 1.2368 | 1.6833 | | 2.0933 | | 1.7673 | | 2.6139 | | 2.2714 | |
| 单个高值 | 2.2231 | 1.8235 | | 1.1432 | | 2.3945 | | 1.7536 | | 1.4751 | |
| 两个低值 | 0.3822 | 0.5596 | | 0.7936 | | 0.5386 | | 0.6566 | | 0.7330 | |
| 两个高值 | 0.7372 | 0.6447 | | 0.5417 | | 0.5690 | | 0.3796 | | 0.3291 | |
| Al2O3 | | | | | | | | | | |
| 统计量 | 水平1 | | 水平2 | | 水平3 | | 水平4 | | 水平5 | |
| 单个低值 | 1.9027 | | 2.2909 | | 1.6867 | | 2.0951 | | 2.2763 | |
| 单个高值 | 1.8810 | | 1.6793 | | 2.4101 | | 1.2564 | | 1.6413 | |
| 两个低值 | 0.6677 | | 0.6491 | | 0.4870 | | 0.7734 | | 0.7425 | |
| 两个高值 | 0.5499 | | 0.4558 | | 0.7316 | | 0.5270 | | 0.3953 | |

结果表明：均满足要求。

**4、Sr、SR、R与r的计算**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Cr | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 | 水平6 |
| 总平均值 | 0.047 | 0.172 | 0.784 | 1.124 | 1.988 | 3.997 |
| T1 | 5.551 | 21.672 | 104.286 | 132.5834118 | 250.509 | 475.587 |
| T2 | 0.2605 | 3.7336 | 81.7956 | 149.0192 | 498.2016 | 1901.0560 |
| T3 | 119 | 126 | 133 | 118 | 126 | 119 |
| T4 | 833 | 882 | 931 | 820 | 882 | 833 |
| T5 | 0.0006342 | 0.0055122 | 0.0249977 | 0.0250172 | 0.1463724 | 0.2589815 |
| Sr2 | 0.0000062 | 0.0000510 | 0.0002193 | 0.0002502 | 0.0013553 | 0.0025390 |
| SL2 | 0.0000132 | 0.0000435 | 0.0001620 | 0.0004124 | 0.0010497 | 0.0028392 |
| SR2 | 0.0000194 | 0.0000946 | 0.0003813 | 0.0006626 | 0.0024050 | 0.0053782 |
| Sr | 0.0024935 | 0.0071442 | 0.0148080 | 0.0158168 | 0.0368144 | 0.0503888 |
| SR | 0.0044099 | 0.0097248 | 0.0195262 | 0.0257405 | 0.0490409 | 0.0733362 |
| r | 0.0070567 | 0.0202179 | 0.0419067 | 0.0447616 | 0.1041848 | 0.1426004 |
| R | 0.0124800 | 0.0275211 | 0.0552593 | 0.0728455 | 0.1387857 | 0.2075416 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Al2O3 | 水平1 | 水平2 | 水平3 | 水平4 | 水平5 |
| 总平均值 | 0.704 | 1.632 | 4.102 | 5.965 | 8.026 |
| T1 | 88.725 | 192.6315294 | 516.873 | 787.3522105 | 1067.409 |
| T2 | 62.5051 | 314.4645 | 2120.5419 | 4697.8180 | 8568.3087 |
| T3 | 126 | 118 | 126 | 132 | 133 |
| T4 | 882 | 820 | 882 | 918 | 931 |
| T5 | 0.042671 | 0.083421 | 0.398700 | 0.602813 | 1.016423 |
| Sr2 | 0.000395 | 0.000826 | 0.003692 | 0.005335 | 0.008916 |
| SL2 | 0.000179 | 0.001000 | 0.001512 | 0.010651 | 0.012038 |
| SR2 | 0.000574 | 0.001826 | 0.005203 | 0.015986 | 0.020954 |
| Sr | 0.019877 | 0.028739 | 0.060759 | 0.073039 | 0.094425 |
| SR | 0.023950 | 0.042731 | 0.072135 | 0.126434 | 0.144756 |
| r | 0.056252 | 0.081332 | 0.171948 | 0.206699 | 0.267221 |
| R | 0.067780 | 0.120929 | 0.204143 | 0.357808 | 0.409659 |