Using Chromeleon® in a Networked Environment

1 INTRODUCTION

In recent years, the trend for many laboratories has been to move from storing their chromatography data on single workstations to storing their data in a centralized area on a networked server. The main reasons for this trend are:

• Easier data access — Data can be accessed from anywhere on the network.
• Easier data management — Backup and archive procedures are simplified.
• Easier data comparison — Because all data is stored in a single location it becomes easier to compare one chromatogram to another, or to compare one set of results to another.

Although the benefits are clear, there are several challenges that companies must face before they are able to implement a networked chromatography system. These include:

• Data security
  – How can data be secured against unauthorized changes?
  – How can data be recovered in the event of a server crash?
• Data Searching
  – How quickly can I find the relevant data in the large amount of centrally stored data?
• Application availability
  – Will it be possible to run my chromatography application in the event of a network failure?
• Infrastructure
  – Will my IT infrastructure be able to meet the demands of a networked chromatography data management system?

This document describes the inherent problems caused by storing data on single workstations, the benefits of moving to a networked chromatography data system, and the ways in which Chromeleon can help companies meet networking challenges.
2 TRADITIONAL ENVIRONMENT

Traditionally, laboratories have stored chromatography data on the hard disk of the computer that runs the hardware control software. As more instruments are purchased, more computers are purchased. In addition, it is often necessary to perform different analyses on different instruments. These factors lead to data being stored in different locations (Figure 1).

The situation becomes more complicated if instruments from different vendors are used. These instruments typically require vendor specific software to acquire and process data (Figure 2). In this case, not only is data spread out, but it is also not transferable between applications.

With regard to administration and regulatory compliance, the traditional environment also has problems. Because the computers are not networked, each computer must be administered separately (especially with data backup and archiving). As more and more computers are used, administrative time and costs necessarily increase.

Similarly, regulatory compliance is almost impossible to achieve in the traditional environment without using up a vast amount of resources. To comply with regulations, each computer running the application must be set up separately and then validated to ensure compliance.

2.1 Main Disadvantages with Localized Environment

- Data is not readily available from any location in the laboratory
- Data cannot be transferred from one application to another
- Trending and querying of data is not possible
- Backup and archive procedures are complicated
- Validation is costlier and more time-consuming because more than one application and individual instances of the application must be validated.
- Training costs are higher because each user must be trained on multiple software packages.
3 NETWORKED ENVIRONMENT

By moving data storage to a centralized location, many of the problems associated with the traditional environment are eliminated. Figure 3 shows how a centralized data storage system improves access to data from any point on the network. This scenario works well if all instruments on the same network are identical and can be controlled with the same software application. However, as soon as different instruments are introduced, centralized data storage becomes more complicated (Figure 4).

To achieve a true networked solution, a chromatography data system capable of controlling and acquiring data from multiple different instruments is required. This solution must also be capable of meeting the challenges inherent in a networked environment. The Chromleon Chromatography Data Management Software is designed to provide this solution.

4 BENEFITS OF A NETWORKED CHROMELEON INSTALLATION

The benefits of operating Chromleon in a networked environment are numerous and explained in more detail in the following sections. In general, a networked Chromleon installation offers the following benefits:

- Improved Instrument Control
  - Chromleon can control over 260 instruments from more than 25 different manufacturers
  - All instruments can be controlled from any point on the network

- Easier data management
  - Data from all instruments can be stored in a single location
  - Data generated by different instruments can be compared and trended
  - Backup and archive is simplified

- Improved laboratory workflow
  - Methods can be transferred easily between departments
  - Centralized templates can speed up data acquisition, processing and reporting

Figure 3. Centralized data storage for one chromatography data system.

Figure 4. Centralized data storage for several different chromatography data systems. In this solution, several different centralized servers must be used, data still cannot be compared easily, and validation and training costs are still high.
4.2 Easier Data Management

In a networked environment all data from all instruments can be stored in a single location. This allows for:

- Easier backup and archive of the data
  - A single data location must be backed up or archived instead of multiple locations.
- Simplified data comparison
  - Figure 5 shows a comparison of an assay of a compound against a reference chromatogram. By using Chromeleon, reference chromatograms are easily obtained from different instruments and even from data acquired several years before the assay chromatogram.
- Simplified data trending
  - Figure 6 shows a trend plot of stability data (assay results) over a one-year period. In this example, centralized data storage ensures that locating and summarizing data, normally a long and time-consuming process, can now be performed in a matter of seconds.

The following sections explain how it is possible to achieve all of this with Chromeleon.

4.1 Improved Instrument Control and Use

Chromeleon can control over 260 chromatography instruments from more than 25 different manufacturers, including widely used instruments from Agilent, Waters, and Shimadzu. Instrument control includes data acquisition from advanced detectors such as diode array detectors.

This capability ensures that all instruments in a laboratory can be controlled using a single software application. This removes the burden of having to operate multiple, different software systems.

In a Chromeleon networked environment every instrument is available for monitoring and control from any point on the network. This means that it is no longer necessary for operators to stand next to the instrument in order to make changes to the instrument conditions, such as changing pump flow or detector wavelength.

For example, in method development it is common to run a sample, check the chromatogram, modify the instrument settings (e.g., change mobile phase conditions), and then run the sample again. With Chromeleon, this can all be performed from the operator’s desk.

Finally, having a common user interface lowers training time and costs for instruments. Instead of learning how to work with different interfaces for different instruments, users need only learn how to work with one interface.

---

**Figure 5.** Comparison of an assay chromatogram against a reference chromatogram.

**Figure 6.** Trend of stability data over a one-year period.
4.3 Improved Laboratory Workflow

When all data is available from a centralized location, it becomes easier to circulate knowledge to all users. For example:

- Methods can be transferred with ease from one department to another.
- Templates can be set up which enable users to quickly create and run sequences and then process and report the acquired data.

Method transfer becomes as simple as copying an instrument method and data processing method from one directory to another. For example, the R&D department can develop an analytical method and place it in their R&D directory. Once finalized, this method can then be copied to a QC directory for validation and, once validated, copied to a new directory for use.

Workflows can also be simplified in order to increase laboratory productivity. For example, instrument control templates, data processing templates, and data reporting templates can be accessed from any point on the network, thus speeding up the time it takes to create, process, and report a sequence.

Figure 7 demonstrates how a centralized data storage area can speed up overall analysis times. In this example, a user can start a sequence running by copying the sequence into the “Data” folder, renaming the samples accordingly, and renumbering the vial positions if required. Then the sequence can be initiated immediately.

4.4 Enhanced Regulatory Compliance

There are several ways in which a networked Chromeleon installation provides enhanced regulatory compliance (for the purposes of this document, the 21 CFR Part 11 regulation will be used as an example).

4.4.1. Data Security

Because all the data is stored in one location, data security is both simplified and enhanced.

Data security is simplified as there is no need to introduce secure storage methods on individual computers. Because the data is not stored on individual computers, the need to introduce secure methods on individual computers is eliminated.

In addition, unlike with the traditional environment, only one location needs to be backed up and, in the event of a server failure, data can be quickly recovered.

For data processing, the user only needs to ensure that the integration parameters are correct and that all sample and standard weights are correct. All other data processing variables (e.g., calibration plot settings, peak names, etc.) are already defined within the data processing template.

For data reporting, the user need only use the existing data report template. The need to make changes is eliminated.

This simplified workflow ensures that overall analysis times are minimized, training costs reduced, and the possibility of analyst error lessened significantly.

Figure 7. Example of template sequence and associated instrument control, data processing, and data reporting templates.
4.4.2 Application Security

21 CFR Part 11 requires that users log on to an application using a user ID and password. A networked Chromeleon installation allows the use of a centralized user security management tool that stores user IDs, passwords, and security settings. In the traditional environment, these security settings would have to be managed on each individual computer. With Chromeleon they can be managed in a centralized area, which is accessible from any point on the network.

User ID and password management is further simplified through the ability of Chromeleon to interface directly with Lightweight Directory Access Protocol (LDAP), such as Microsoft Active Directory. In this case, security settings within Chromeleon are still controlled through the user security management tool, but passwords are managed through the operating system tools.

4.4.3 Validation

The validation effort for a networked system is considerably lessened than for the traditional environment for two reasons:

1. Because Chromeleon can control so many different instruments, there is no need for additional chromatography applications. This means you need only validate one application rather than several.
2. The Chromeleon datasource and user management database are held in a single area, so the application need only be validated once. If these components were stored on several different computers, they would all need to be validated separately.

4.5 Lower Administration Costs

Administration costs are reduced because all data is located in a single location and, therefore, only one location requires backup and archive steps. In a traditional environment with more than one computer, these costs are increased each time a new computer is installed.

Also, in the traditional environment, each computer running the application must be administered separately. In a networked environment, each computer can be administered from a single centralized location containing all the data so that administration time is reduced.

Although it is difficult to calculate exact administration values (these vary according to use), Figure 8 shows that for installations of approximately five or more computers, administration costs are significantly lower than for those in a traditional installation.

Finally, Chromeleon is tested and validated to work with Windows Terminal Services and Citrix Server, so that instead of installing Chromeleon on multiple remote clients, it is installed once on a single server. The application is then run remotely from this source. This mode of operation offers two key benefits:

1. Installation time is vastly reduced, as well as the amount of installation paperwork required (such as IQ, OQ, and PQ documentation).
2. Upgrades of the application are easier to manage because it is only necessary to upgrade the single version running on the Terminal or Citrix Server.

4.6 Lower Training Costs

Due to the availability of all data from a centralized area, it becomes easier to adapt the software so that it becomes simpler to use. Section 4.3 demonstrated how the use of centralized templates reduces overall analysis times, but there are other ways in which the training burden is reduced:

1. All chromatography data is accessible from a single application. There is no need to train users on separate chromatography applications.
2. All instruments are controlled through a single Chromeleon interface so users do not need to learn how to work directly with each instrument interface.
3. Centralized training areas can be set up on the data storage area that provide users with real-life training examples. For example, pre-prepared sequences that demonstrate how different integration or calibration settings can easily be set up and then accessed by new users.
5. OPERATION OF CHROMELEON IN A NETWORKED ENVIRONMENT

The Chromeleon Chromatography Management System is designed to operate in either stand-alone mode or in networked mode. Figure 9 shows an example of a networked installation. In stand-alone mode, workstations are not connected to the network.

As can be seen in the figure, data is stored on the file/database server and is accessible from anywhere on the network. In addition, all instruments are connected to the network and can be monitored and controlled from any computer running Chromeleon. The following sections describe each of the main components of the network. All these components are simple to install and the whole process can be accomplished quickly.

5.1 Overview of Chromeleon Components

Table 1 shows which Chromeleon Components are installed on which areas of the network.

5.2 Chromeleon Datasource

Chromeleon stores data using a hybrid database/flat file structure in a container called a “Datasource”. All large binary objects such as instrument control methods, processing methods, report methods, and raw data are stored as files in an NTFS folder. All sample information, links to associated external files, and history information is stored in a relational database. This architecture combines all features of a relational database with the fast response times provided by file-based architectures.

For network installations, Dionex recommends either Oracle® or Microsoft SQL Server as the database. Note that multiple datasources can be created using the same database and file server.

In Figure 9, the database server and file server are on the same computer. However, if required, these can be separated. For example, the database can run on a UNIX server, and a separate Windows server can be used as the file server.

5.3 Chromeleon User Database

The Chromeleon User Database stores global security settings such as minimum password length and user account settings such as account names, passwords, and privilege and access levels (Figure 10).

If required, the User Database can be interfaced with a centralized user management application such as Active Directory. In this case, password information is not managed by the Chromeleon User Database, but is instead managed by the centralized user management application.

Unlike the Chromeleon Datasource hybrid storage model, all data associated with the Chromeleon User Database is stored within a database. For network installations, Dionex recommends either Oracle or Microsoft SQL Server as the database.

Note: This can be the same database as the one used for the Chromeleon Datasource.
5.4 Chromeleon Server

The Chromeleon Server is a background application that monitors and controls an instrument. It executes programs, sequences, and batches that are stored on a datasource and saves data from an instrument as a channel into the same datasource.

The Chromeleon Server is the only component that communicates directly with an instrument. Therefore, to control an instrument, the computer running the Chromeleon Server must be physically connected to the instrument through a DX-LAN, USB, or other connection protocol. The Chromeleon Server runs on Laboratory Workstations and Instrument Servers.

5.5 Chromeleon Client

The Chromeleon Client is the User Interface (UI) component of the Chromeleon software. It uses a Browser interface to interact with the Chromeleon Datasource, and a Control Panel to interface with the Chromeleon Server (Figure 11).

The Chromeleon Client runs on Laboratory Workstations, Remote Clients, and the Terminal/Citrix Server.

5.6 Chromeleon License Server

The Chromeleon License Server is typically installed on the file server and provides licenses to all computers running Chromeleon on the network. Two distinct types of licenses are provided.

5.6.1 Server Licenses

Server licenses are assigned to computers running the Chromeleon Server software module and grant these computers specific control options, such as control of Diode Array detectors. This license is linked to a specific computer name. If the License Server is unavailable for any reason, the computer will retain its license for seven days. This time period is reset once the License Server becomes available again.

5.6.2 Client Licenses

Client licenses are assigned on a concurrency basis and grant computers specific Chromeleon options, such as GLP security options. The concurrency model allows the Chromeleon Client module to be installed on as many computers as required without requiring the purchase of more licenses. Licenses are only used when the software is running.

Figure 11. Chromeleon Client displaying both the Browser view and a Panel view.
6 HOW CHROMELEON ADDRESSES THE CHALLENGES OF A NETWORKED ENVIRONMENT

When moving to a networked environment, there are several challenges that must be met:

• Data security
  – How can data be secured against unauthorized changes?
  – How can data be recovered in the event of a server crash?

• Data searching
  – How quickly can I find the relevant data in the large amount of centrally stored data?

• Application availability
  – Will it be possible to run my chromatography application in the event of a network failure?

• Infrastructure
  – Will my IT infrastructure be able to meet the demands on a networked chromatography data management system?

With Chromeleon, it becomes simple to overcome these challenges.

6.1 Data Security

Data security is a major challenge in a networked environment. Steps must be taken to ensure that only authorized users are allowed to access the data, and also that the users are only allowed to perform authorized tasks (e.g., users may be allowed to create data, but not delete it). Other steps must be taken to ensure that data is not lost, either due to a server crash or a network failure. Chromeleon has many built-in and easy-to-use features that ensure security of data.

6.1.1 Securing Data Against Unauthorized Changes

Section 5.3 provides details on how the Chromeleon User Database controls what users can and cannot do from inside the application. For example, if it is required that no users be allowed to delete data, this privilege is denied to all users in order to enforce compliance.

Of additional interest to IT administrators is how to ensure that data cannot be created, modified, or deleted using a non-Chromeleon application. That is, how can the data created by Chromeleon be protected from users trying to gain access from applications such as SQL Plus (for the database entries) and Windows Explorer (for the external files)? This is accomplished through the use of three security components:

• Database Security
• NTFS Security
• Chromeleon Transaction Agent Service

6.1.1.1 Database Security

A Chromeleon Datasource requires a database (such as Oracle or SQL Server). When creating a database for use with Chromeleon, it is necessary to create a database account that can be used by Chromeleon. When a connection is made to the database, the account name and password must be entered to finalize the connection. This connection needs to be created only once and is typically performed by a Dionex engineer or an IT administrator. Chromeleon users do not need to be provided with the account name or password, thus preventing them from accessing the database entries using applications such as SQL Plus.

6.1.1.2 NTFS Security

A Chromeleon Datasource also requires a raw data folder. When creating a folder for use with Chromeleon, it is necessary to first create a Windows Account that can be used by Chromeleon. Only this account (and any high level accounts such as Domain Administrators) is granted access to the raw data folder (at both the share and security level). User accounts are not granted any access. These account details are then provided to the Chromeleon Transaction Agent Service (see next section).

6.1.1.3 Chromeleon Transaction Agent Service

A service called the Chromeleon Transaction Agent is installed as part of the Chromeleon installation process. It governs all transactions between the Chromeleon Client and the datasource (Figure 12). Because the Transaction Agent Service has been granted these rights, the user is prevented from accessing the raw data through applications such as Windows Explorer, but can still access it using Chromeleon.

Figure 12. General principles of the Chromeleon Transaction Agent.

Local PC
User is logged on as “User”

Central Server with Chromeleon Datasource

CM Client Application
CM Transaction Agent
CM Database

CM Files "Modify" access right is granted for “TA”
For other users no access rights are granted

Windows Explorer and Other Applications

“User”

“TA”

Technical Note 65
6.1.2 Avoiding Data Loss

Data stored on servers can be easily protected through a regular backup of the server. However, in a networked chromatography environment there are other challenges to consider because chromatography instruments generate data for long periods, even when there is no user interaction. There are 2 modes of collecting this data in a networked environment:

- Data is collected directly to the data storage area.
- Data is collected on to the acquisition computer. Once collection is completed it is moved to the central data storage area.

Chromeleon supports both these modes of data collection. Both have their advantages and disadvantages, as discussed below.

6.1.2.1 Model 1: Centralized Data Acquisition with Network Failure Protection

If data acquisition is performed directly to a centralized datasource, the Chromeleon Server continually buffers the data for a period of about 5 s before sending it through the network to the datasource. The instant a communication failure is detected (such as a server hard disk failure or a network failure) the Chromeleon server switches over to Network Failure mode. In this mode, the data is continually buffered on the local hard disk of the acquisition PC until communication with the datasource is regained. At that point, all buffered data is transferred from the local hard drive to the network datasource. This functionality ensures that data is not lost at any time or for any reason.

**Advantages:** Using this model, data is immediately available on the network for review and processing—even during data acquisition.

**Disadvantages:** Data cannot be reviewed or processed during network failure mode.

This mode is recommended for laboratories that need fast access to data from all points on the network at all times. For laboratories that require constant access to data, even during network failure, Model 2 is recommended.

6.1.2.2 Model 2: Local Data Acquisition with On-Line Transfer Agent

Each instance of a Chromeleon Server installation contains a local datasource, which uses an access MDB container as the database. Data acquisition can be performed here instead of on the network datasource. The Chromeleon On-Line Transfer Agent tool will detect when the data acquisition is complete and then automatically transfer the data to the network datasource.

**Advantages:** Data is available for review and processing at all times, even during network failure.

**Disadvantages:** Data is only available on the network once the sequence has finished. During data acquisition, data review/processing must generally take place at the PC acquiring the data.

6.2 Data Searching

When there is a large amount of data stored in a single location, it can be difficult to quickly locate specific data sets, especially if the data is several years old.

Chromeleon provides a solution to this problem through the use of an integrated query feature. This tool makes it easy to query data based on several key characteristics, such as sequence details, sample details, and even chromatography results. For example, if a user is searching for any data that was acquired in the first month of 2005 and contained a peak named “Uracil”, they are able to do so easily using the Query Wizard (Figure 13).

**Figure 13. Using the Chromeleon Query Wizard to Find Data.**
On execution of the query, Chromeleon automatically locates all samples and chromatograms which match the search criteria and displays them as a virtual sequence with all the relevant sequences in the header, and all relevant samples in the sample list (Figure 14).

Simple queries can take a matter of seconds to execute, whereas more complex queries (especially those which query results) can take several minutes. However, this is several orders of magnitude faster than attempting to search manually through very large data sets.

6.3 Application Availability

Another challenge is to ensure that it is still possible to run the application in the event of a server crash or network failure. Although it is obvious that any data stored on the server is unavailable at these times, users still need to be able to analyze any new samples they receive.

With Chromeleon, this is still possible because all Chromeleon Workstations (those PCs which are connected directly to the instruments) contain all components necessary to perform this work. That is, they all come preinstalled with a local datasource (based on MS Access) that can be used in this type of emergency situation. Once the networked server is available again, any data stored on the local datasource can be manually transferred or transferred automatically via the Chromeleon On-Line Transfer Agent. These Chromeleon Workstations will even work correctly if the License Server is not available because all workstations remember their license settings for seven days.

6.4 Infrastructure Demands

A common challenge is to ensure that the IT infrastructure is able to meet the demands of a networked installation. With Chromeleon, this is simple. The client/server architecture of Chromeleon ensures that network traffic is kept to a minimum so that it is easy to add your current systems to the network, followed by new systems, without having to update the network. New instruments and computers may be added to an existing networked installation without significantly affecting the performance of the installation.

Figure 14. Virtual sequence generated from a query.
APPENDIX A—TECHNICAL SECTION

A1 Compatibility
Chromeleon is currently compatible with (and has been validated on) the following applications:
• Microsoft Windows 2000 (All service packs)
• Microsoft Windows XP (All service packs)
• Microsoft Windows 2003 Server
• Oracle 8i (8.1.7.0.0), Oracle 9i (9.0.1.1.1), Oracle 10g Release 2
• Microsoft SQL 7, Microsoft SQL 2000
• Microsoft Jet Engine 4 (Access MDB Format)
• Citrix Meta frame XP version 1.00
• Citrix ICA Client version 7.00.17534
For updated information, please refer to the current release notes or contact your local Dionex representative.

A2 Installation Requirements
A networked Chromeleon installation requires the following centralized resources:
1. Chromeleon License Server—Manages the software licenses for all PCs running Chromeleon.
2. Chromeleon Datasource—The central data storage area.
3. Chromeleon User Database—Stores user IDs, passwords, and security settings.
4. Terminal Server (optional)—Used to centrally manage Chromeleon Client installations.

The following distributed resources are also required:
1. Chromeleon server—Controls the chromatography instruments.
2. Chromeleon client—The main application used to access, process, and report data. This can be distributed on as many PCs as required, either manually or using a roll-out package. Alternatively it can be installed on a Terminal Server.

The installation requirement for each of these is covered in more detail in the following sections.

A2.1 Chromeleon License Server
The PC requirements are the same as those of the operating system specification. The specifications for Windows 2003 Server (Standard Edition) are shown in Table 2.

<table>
<thead>
<tr>
<th>Computer and processor</th>
<th>PC with a 133-MHz processor required; 550-MHz or faster processor recommended USB port must be available for the license device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>128 MB of RAM required; 256 MB or more recommended; 4 GB maximum</td>
</tr>
<tr>
<td>Hard disk</td>
<td>1.25 to 2 GB of available hard-disk space</td>
</tr>
<tr>
<td>Optical drive</td>
<td>CD-ROM or DVD-ROM drive</td>
</tr>
<tr>
<td>Display</td>
<td>VGA or hardware that supports console redirection required; super VGA supporting 800 x 600 or higher-resolution monitor recommended</td>
</tr>
</tbody>
</table>

A2.2 Datasource
A Chromeleon datasource requires both a database and a raw data folder. The requirements for each of these are detailed in this section (Table 3 and 4).

A2.2.1 File Server Requirements
The file server requirements are the same as those of the operating system requirements, with the exception of the hard disk space required.

The hard disk requirements are dependent on the number of instruments used by the laboratory and the type of data generated. Hard disk space requirements can be estimated using the figures in Table 3. There are a large number of different ways in which these values can be combined, and it is difficult to provide an exact figure for the hard disk requirement per instrument. However, it is likely that data and metadata created by each instrument per year will be less than 500 MB for 2-D data acquisition.
### A2.2.2 Database Server Requirements

The database server requirements are the same as those for the database requirements, with the exception of the hard disk space required (Table 4).

The hard disk requirements are dependent on the number of samples run by the laboratory and the type of data processing performed. Hard disk requirements can be estimated using the figures in the table below. It is difficult to provide a general figure, however, it is likely that the amount of data generated per instrument per year will be less than 30 MB.

Full details on creating and configuring an Oracle or SQL Server database for use with a datasource are available from Dionex upon request.

### A2.3 Chromeleon User Database

Unlike the Chromeleon datasource, the Chromeleon User Database stores no raw data files. All information is stored inside the associated database (Table 5).

### A2.3.1 Database Server Specification

Database Server Specifications are the same as the specifications for the Chromeleon Datasource, with the exception of hard disk requirements. The specifications depend on the number of users, privilege, and access groups stored, and the number of history entries (such as user login details and changes to the database). Hard disk requirements can be estimated using the figures shown in Table 5.

The figures shown above are very low. This means that whatever disk requirements are calculated for the datasource will also be sufficient for the user database.

---

#### Table 3. File Server Requirements (Same as for the OS + Extra Hard Disk Space)

<table>
<thead>
<tr>
<th>PC Requirements (Example: Windows 2003 Server Std. Ed.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer and processor</td>
<td>PC with a 133-MHz processor required; 550-MHz or faster processor recommended</td>
</tr>
<tr>
<td>Memory</td>
<td>128 MB of RAM required; 256 MB or more recommended; 4 GB maximum</td>
</tr>
<tr>
<td>Hard disk</td>
<td>See below</td>
</tr>
<tr>
<td>Optical drive</td>
<td>CD-ROM or DVD-ROM drive</td>
</tr>
<tr>
<td>Display</td>
<td>VGA or hardware that supports console redirection required; Super VGA supporting 800 x 600 or higher-resolution monitor recommended</td>
</tr>
</tbody>
</table>

#### Hard Disk Requirement for Chromatography Data

| 2D Data | 80 KB per instrument per hour |
| 3D Data | 20 000 KB per instrument per hour |

#### Hard Disk Requirement for Meta Data

| Program files | 2.5 KB each |
| Quantification method files | 6.0 KB each |
| Report definition files | 250 KB each |

#### Table 4. Database Server Requirements (Same as for the OS + Extra Hard Disk Space)

<table>
<thead>
<tr>
<th>PC Requirements - Oracle 9i Standard Edition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer and processor</td>
<td>PC with a 200-MHz or faster processor required; 266-MHz or faster processor recommended</td>
</tr>
<tr>
<td>Memory</td>
<td>128 MB of RAM required; 256 MB or more recommended</td>
</tr>
<tr>
<td>Hard disk</td>
<td>3 GB (NTFS drives) + Chromeleon data requirements (see below)</td>
</tr>
<tr>
<td>Optical drive</td>
<td>CD-ROM or DVD-ROM drive</td>
</tr>
<tr>
<td>Display</td>
<td>Video adapter; 256 Colors</td>
</tr>
</tbody>
</table>

#### Hard Disk Requirements for Chromatography and Meta Data

| Per sample | 100 bytes |
| Per sequence | 1300 bytes |
| Per history entry† | 400 bytes |

#### Additional Database Requirements

| Oracle | 1 tablespace per datasource |
| SQL server | 1 database per datasource |
| 1 user account per datasource |

†Activation of history mode is optional.

#### Table 5. Hard Disk Requirements for the User Database

| Per user | 500 bytes |
| Per privilege group | 500 bytes + 700 bytes per user assigned |
| Per access group | 500 bytes + 85 bytes per user assigned |
| Per history entry | 50 bytes |
A2.4 Chromeleon Client/Server
Both these applications require the same PC specification (Table 6).

A2.5 Terminal Services
Chromeleon Client can be operated with a Windows Terminal Server or a Citrix server which offers two main advantages: (1) The application needs to be installed only once, and (2) that upgrades are easier to manage.

A2.5.1 Server Specification
The server requirements (based on a maximum of 20 concurrent users) are shown in Table 7.

Note: For 30 or more users, Dionex recommends multiple servers.

A2.5.2 Client Specification
If Chromeleon Client is run using Citrix, the PC requirements are significantly lower than running Chromeleon Client from the PC hard disk (Table 8).

Table 7. PC Requirements for the Terminal Server

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer and processor</td>
<td>PC with a 800-MHz processor or faster required</td>
</tr>
<tr>
<td>Memory</td>
<td>1 GB of higher of RAM required</td>
</tr>
<tr>
<td>Hard disk</td>
<td>1 GB or higher required</td>
</tr>
<tr>
<td>Optical drive</td>
<td>CD-ROM or DVD-ROM drive</td>
</tr>
<tr>
<td>Display</td>
<td>VGA or hardware that supports console redirection required; Super VGA supporting 800 x 600 or higher-resolution monitor recommended</td>
</tr>
</tbody>
</table>

Table 8. PC Requirements for the Thin Client

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer and processor</td>
<td>PC with a 100-MHz processor or faster required</td>
</tr>
<tr>
<td>Memory</td>
<td>64 MB of RAM or higher required</td>
</tr>
<tr>
<td>Hard disk</td>
<td>As per operating system requirements</td>
</tr>
<tr>
<td>Optical drive</td>
<td>CD-ROM or DVD-ROM drive</td>
</tr>
<tr>
<td>Display</td>
<td>VGA or SVGA video adapter</td>
</tr>
</tbody>
</table>

1 If data is acquired locally before transfer to the network, disk space requirements are higher.